Permit Modification Request

Amended Closure Plan

Waste Isolation Pilot Plant Carlsbad, New Mexico

WIPP HWFP #NM4890139088-TSDF





Department of Energy

Carlsbad Field Office
P. O. Box 3090
Carlsbad, New Mexico 88221
October 7, 2002

Mr. John R. D'Antonio, Jr., Secretary New Mexico Environment Department 1190 St. Francis Drive Santa Fe, NM 87502

Subject: Permit Modification Request: Closure Plan Amendment

Dear Secretary D'Antonio:

This submittal requests a permit modification to the Waste Isolation Pilot Plant (WIPP), Hazardous Waste Facility Permit (HWFP), Number NM4890139088-TSDF. This request is being submitted by the U. S. Department of Energy, Carlsbad Field Office (CBFO) and the Westinghouse TRU Solutions LLC pursuant to 20 New Mexico Administrative Code (NMAC) 4.1.900 (incorporating 40 CFR 270.42). We are herein requesting approval of an amended Closure Plan, which describes the advantages of an alternative panel closure system (PCS). We are also requesting a change in the closure schedule, and NMED's determination that this submittal represents a "Class 2" Permit Modification Request (PMR).

We anticipate the need to close Panel 1 in January 2003. When the panel is full, WIPP HWFP Condition II.L.4.a (20 NMAC 4.1.500) (incorporating 40 CFR 264.113) requires the construction of the approved closure as described in Attachment I, commonly known as the "Option D" design.

Over the last two years, we have been evaluating Option D, and in particular the viability of installing the Salado Mass Concrete (SMC) monolith. While conducting test pours of the specified SMC, we have been simultaneously evaluating a range of alternatives to the Option D design. The two fundamental conclusions of this analysis are:

- It may be difficult to meet the HWFP specifications for the Option D installation.
- We have identified an alternative PCS (the WIPP Panel Closure, or WPC) that
 provides significant advantages over Option D, with no sacrifice in the protection
 of human health or the environment.

The deployment of the SMC monolith in accordance with the Option D specifications requires innovative equipment and materials in the underground environment. The proposed WPC design meets all of the performance specifications and regulatory requirements, but is constructed using conventional techniques and materials.



ee. General Manager

Westinghouse TRU Solutions LLC

In addition to increasing the probability of a successful closure, the use of proven methods also provides several significant advantages. The WPC, as compared to Option D:

- Lowers potential risks to workers because it involves fewer and less complex construction activities and associated man-hours.
- Creates less impact on underground operations because materials delivery can be conveniently staged into the underground, and construction activities can be scheduled, as time and space permit.
- Takes less time to install (estimated 5 months vs. 14 months).
- Is less expensive to install (estimated cost savings of approximately \$1.3 million in 2002 dollars for each panel.
- Provides for use, rather than disposal, of mined salt per the intent of the Resource Conservation and Recovery Act.

The enclosed Permit Modification Request and supplemental information demonstrate how the WPC meets each of the HWFP performance standards. The PMR and supporting documents also describe how the WPC is at least as protective of human health and the environment as Option D.

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision according to a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fines and imprisonment for knowing violations.

We respectfully request your consideration of the enclosed PMR. Please contact Mr. Jody Plum at (505) 234-7462 with your questions or comments. We would be pleased to meet with you at your convenience to discuss this request.

Sincerely,

Dr. Inés R. Triay, CBFO Manager

U. S. Department of Energy

Enclosures

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ACRONYMS AND ABBREVIATIONS

ASTM American Society for Testing and Materials

CFR Code of Federal Regulations

CH Contact Handled

D&D Decontamination and Decommissioning

DOE U.S. Department of Energy DRZ Disturbed Rock Zone

EPA Environmental Protection Agency
FLAC Fast Lagrangian Analysis of Continua
HWDU Hazardous Waste Disposal Unit
HWFP Hazardous Waste Facility Permit

MSHA U.S. Mine Health and Safety Administration

NMAC New Mexico Administrative Code NMED New Mexico Environment Department

PCS Panel Closure System
PMR Permit Modification Request
PMS Permanent Marker System
PPE Personal Protective Equipment

QA Quality Assurance QC Quality Control

RCRA Resource Conservation and Recovery Act

SAR Safety Analysis Report SWB Standard Waste Boxes

TRU Transuranic

TSDF Treatment, Storage and Disposal Facility

VOC(s) Volatile Organic Compound(s)
WAC Waste Acceptance Criteria
WHB Waste Handling Building
WIPP Waste Isolation Pilot Plant
WPC WIPP Panel Closure

OVERVIEW OF THE PERMIT MODIFICATION REQUEST

This document contains a Permit Modification Request (**PMR**) for the Hazardous Waste Facility Permit (**HWFP**) at the Waste Isolation Pilot Plant (**WIPP**), Permit Number NM4890139088-TSDF (WIPP HWFP). This PMR is being submitted by the U.S. Department of Energy (**DOE**), Carlsbad Field Office and Westinghouse TRU Solutions LLC, collectively referred to as the Permittees, in accordance with the WIPP HWFP Condition I.B.1 (20.4.1.900 New Mexico Administrative Code (**NMAC**) (incorporating Title 40 Code of Federal Regulations (40 **CFR**) §270.42)). This modification proposes a revision to the approved closure plan. These changes do not reduce the ability of the Permittees to provide continued protection of human health and the environment.

Associated with submittal of this PMR, the Permittees seek a determination by the Secretary of the New Mexico Environment Department (**NMED**) that this modification should be reviewed and approved as a Class 2 modification. The Permittees have organized this modification request to support this request, and the following information specifically addresses how compliance has been achieved with WIPP HWFP Condition I.B.1. All direct quotes are indicated by italicized text.

1. Describe the exact change to be made to the permit conditions and supporting documents referenced by the permit.

This modification request proposes to amend the closure plan by revising the Panel Closure System (**PCS**). The approved PCS, known as "Option D," requires emplacing a 12-foot explosion isolation wall and emplacement of a 26-foot monolith composed of Salado Mass Concrete (**SMC**). The new PCS, referred to as the WIPP Panel Closure (**WPC**), consists of a substantial 30-foot mortared concrete block explosion isolation wall and emplacement of 100 feet of run of mine salt as backfill. The term "run of mine salt" refers to salt obtained from routine mining activities in the WIPP underground and used as backfill. The major components of each system are summarized in the following table:

Option D	WPC
12-foot Explosion Isolation Wall	30-foot Explosion Isolation Wall
26-foot SMC Monolith	100-foot Run of Mine Salt Backfill

This modification primarily entails replacing the Option D specifications and drawings with the WPC specifications and drawings. The WIPP HWFP was the standard used to determine the adequacy of the WPC. The Permittees have determined that the WPC meets the terms of the HWFP and that it is at least as protective as Option D in satisfying the environmental and closure performance standards. The evaluation of the WPC and its level of protectiveness is provided in the attached *Design Report for a Revised Panel Closure System at the Waste Isolation Pilot Plant, Rev. 1, October, 2002.*

The time necessary for closure has been modified to account for installation of the WPC. In evaluating the time necessary for closure, the Permittees considered the *Hazardous Waste Storage and Disposal in Geologic Repositories, Permit Guidance Under the Resource Conservation and Recovery Act* (EPA/530-SW88-001 (OSWER Directive 9523.00-13, March 1988)), which states, "*The closure plan must identify the steps necessary for complete or*

partial closure of the facility at any point during its intended operating life." §10.1 (emphasis added). Following this guidance, the Permittees have identified all of the steps and the associated time frame that would be necessary if closure of a Panel was unexpectedly required. The result is that the Permittees have determined that the partial closure activities will, of necessity, take longer than 180 days to complete and are therefore seeking approval from the Secretary of the NMED of this extended partial closure period in accordance with 20.4.1.500 NMAC (incorporating 40 CFR §264.113(b)(1)(i)).

Associated with modifying the Closure Plan as contained in HWFP Attachment I, the Permittees have updated other pertinent information, i.e., the waste inventory information to be consistent with WIPP HWFP Module IV and the information related to Panel operations start and end dates and closure start and end dates have been updated based on August 2002 throughput estimates.

In summary, the extent of the changes to be made are:

- 1. Replace existing panel closure system with one that has been demonstrated to be equally protective of human health and the environment,
- 2. Revise the schedule for closure to account for the WPC and
- 3. Update throughput information and make waste volume information consistent with the HWFP Module IV.

Attachment A of this PMR explains the individual changes proposed while the exact, proposed changes to the WIPP HWFP are provided in Attachments B and C. Proposed modifications to the text of the WIPP HWFP have been identified using a <u>double underline</u> and a revision bar in the right hand margin for added information, and a <u>strikeout</u> font for deleted information.

2. Explain why the modification is needed.

In early 2001, the Permittees began evaluating installation of Option D as specified in the WIPP HWFP in anticipation of Panel 1 closure. Concerns were identified related to possible impacts that the use of SMC in the installation of Option D could have on waste management activities in the WIPP underground. These initial concerns were reinforced by the erratic results obtained from several test pours of the SMC formulation specified in the WIPP HWFP. The evaluation team concluded that there were significant opportunities for implementing an alternative design, which would be:

- equally protective;
- less impactive to facility operations; and
- have a higher certainty of successful installation.

In early 2002, the Permittees began the process of developing an alternative PCS. The Permittees began preparing the engineering redesign, supporting documents, and assessments necessary to support a revised PCS. The *Detailed Design Report for a Revised Panel Closure System at the Waste Isolation Pilot Plant, Rev. 1, October 2002*, and this PMR, are the results of this program.

<u>Higher Certainty of Success Without Reducing Protectiveness</u>

Option D requires the use of unproven construction materials, in that the SMC formulation specified by the HWFP was developed specifically for use in a very different application (the WIPP shaft seals), and has never been successfully poured in a quantity larger than 5 cubic yards (5-yards) (WIPP is currently in the process of conducting a 30-yard test pour). Each of the 4 cells associated with each Option D monolith will be approximately 120-yards. The size of the pour is important because in recent tests different concerns have arisen with each increase in the size of test pour, i.e., from bench scale, to 1-yard, to 5-yard, to 30-yard.

As previously stated, a testing program was initiated to evaluate the use of SMC as required in the approved closure plan. The program includes a series of bench scale tests and field scale tests. The results of these tests to date are as follows:

Summary of Salado Mass Concrete Tests

ID	Mix Date	Initial Slump (inch)	4 Hour Slump (inch)	28 Day Compressive Strength (pounds per square inch)	
Target Specifications		Max 10	8 after 3 hours intermittent mixing	4500	
Bench Scale Test	S				
SMC1	19Feb02	9.00	_(1)	_ (3)	
SMC2	26Feb02	7.90	8.40	690	
SMC3	25Mar02	7.80	7.00	890	
SMC7	11Apr02	4.75	1.00	3790	
SMC5	16Apr02	7.50	2.00	5070	
SMC6	16Apr02	8.25	1.50	4470	
SMC4	17Apr02	8.00	3.25	4750	
SMC3/2	07May02	7.75	3.50	3720	
SMC3.5	08May02	8.25	5.00	4690	
SMC3.5Hot	09Jul02	3.25	– ⁽²⁾	3870	
Batch Tests					
5yd batch	30Jul02	1.5	_(1)	3135	
1yd batch	20Aug02	7.5	(1)	3570	
30yd batch	24Sep02	_ (4)	(1)	TBD	

⁽¹⁾ Not Measured

These results show that problems were encountered in achieving the WIPP HWFP required SMC strength of 4500 psi at 28 days. As noted above the largest SMC pour to date at WIPP

⁽²⁾ Not Reported

⁽³⁾ Did not set

⁽⁴⁾ Slumps taken from each truck

TBD - to be determined

was 5-yards as part of the current testing program. A larger test (30-yard) is in process. The 30-yard pour represents about one fourth of the amount for one of four cells required in each concrete monolith by the Option D PCS. The Permittees have not concluded that installation of Option D can not be accomplished; however, it may be difficult and the possibility of a failed cell pour, requiring its removal, cannot be overlooked. Conversely, no concerns have been identified associated with the installation of the WPC panel closure system consisting of a 30-foot mortared solid block wall and placement of 100-feet of run of the mine salt as backfill.

<u>Protectiveness</u>

The WIPP HWFP was the standard used to determine the adequacy of the WPC. The Permittees have determined that the WPC meets the terms of the HWFP and that it is at least as protective as Option D in satisfying the environmental and closure performance standards. The evaluation of the WPC and its level of protectiveness is provided in the attached *Design Report for a Revised Panel Closure System at the Waste Isolation Pilot Plant Rev. 1, October, 2002.* The Permittees have determined that the WPC PCS has a higher likelihood of success and will assure equivalent protection of workers, human health, and the environment during the operating phase of WIPP.

Less Impactive to Facility Operations

The Permittees believe a compelling reason to seek this permit modification is that installation of the WPC will be less impactive to facility operations, i.e., surface operations, waste disposal in the WIPP underground, and mining and excavation activities. The following table identifies how the WPC design is less impactive.

Comparison of Option D to WIPP Panel Closure

Item	Option D	WIPP Panel Closure (WPC)
Special Materials	Quartz aggregate must be transported from Minnesota	Run of mine salt available at the WIPP facility
Staging	Salado Mass Concrete must be batched aboveground and transported underground for installation.* Only concrete blocks for the explosion-isolation wall may be pre-staged in the underground.	All construction materials may be pre-staged in the underground.
Forms	Multiple sets of heavy steel forms must be constructed in the confined area of the panel access and exhaust drifts.	No forms required.
Storage	Large quantities of aggregate, cement, fly ash and other materials must be stored aboveground prior to use.	Minor aboveground storage required.

Item	Option D	WIPP Panel Closure (WPC)
Handling/Installation	Salado Mass Concrete must be batched aboveground and bulk, wet concrete transported underground for installation.	Mortar quantities are small and easily prepared.
Salado Mass Concrete	Difficult to obtain correct mix to meet construction specifications in the WIPP HWFP under constraints of underground installation.	Salado Mass Concrete not required.
Special Equipment	Extensive removal and shaping required using specialized equipment.	Simple surface preparation without requiring specialized equipment.
Time to Install	Installation estimated to be 14 months, assuming no failed monolith cells.	Installation estimated to be 5 months.

^{* =} Although the WIPP HWFP provides an option for underground batching, concerns related to water use and increased activity in the underground have all but eliminated this option.

The WPC will also significantly reduce the use of the waste hoist over both the extended construction time for a single Option D, and consequently the life of the facility. Once a pour begins for an individual cell of Option D, dedicated use of the waste hoist is required until the pour is complete. This extended use of the hoist could cause operational delays and create conflicts with waste management activities.

Less Expensive

As part of the redesign process, comparable cost estimates were prepared by the Permittees for Option D and the WPC (Patchet, 2002). It was determined that the cost for installation of the WPC is approximately one-third the cost of Option D. This would result in cost savings of approximately 1.3 million dollars for each WPC and over \$10 million dollars for all of the WPCs. The Permittees believe the ability to save millions of dollars in itself is sufficient reason/need for seeking this permit modification.

Less Risk

It is commonly accepted that less time, transportation, handling, and reduction in complexity translates to lower risk to workers. Two factors are involved in qualitatively estimating the risk reduction associated with installation of the proposed PCS. One factor is the time the workers spend transporting, handling, and installing. The other factor is the complexity of the construction project. As part of the redesign process, the Permittees prepared installation schedules for the Option D PCS and WPC. The underground construction activities for Option D are estimated to require approximately 14 months. The comparable period for construction of the WPC is approximately 5 months. (Patchet, 2002).

The Permittees also reviewed the complexity of the construction project associated with Option D versus construction of the WPC. The WPC construction project uses proven materials and techniques, reducing the number of workers required to be in the proximity of the project. Thus the WPC will yield additional risk reduction benefits to workers.

Summary

The Permittees have identified the following advantages associated with installation of the WPC which include:

- less time to install;
- less material transportation to the site;
- less staging of materials at the surface;
- less complex activity in the underground;
- no construction of forms:
- no placement of bulk, wet SMC in the underground;
- reduction of risks to workers;
- higher certainty of success without reducing protectiveness;
- retain mine salt in the underground for use as backfill;
- less costs; and,
- provide for use, rather than disposal, of mined salt per the intent of the Resource Conservation and Recovery Act.

3. Identify the Class of the Modification.

This modification is not explicitly listed in 20.4.1.900 NMAC (incorporating Appendix I of 40 CFR §270.42), therefore in accordance with 20.4.1.900 NMAC (incorporating 40 CFR §270.42(d)(1)) the Permittees are requesting a determination by the Secretary that the modification should be reviewed and approved as a Class 2 modification.

The regulations at 20.4.1.900 NMAC (incorporating Appendix I to § 270.42-Classification of Permit Modification) relative to "Item D. Closure" contain the following subsections:

- "Item D.1. Changes to the closure plan
- Item D.2. Creation of a new landfill unit as part of closure
- Item D.3 Addition of the following new units to be used temporarily for closure activities:"

This PMR is an exact match with Item D.1. The Permittees have an approved Closure Plan for which a change is being sought. We are not creating a new landfill (Item D.2) nor are we adding new units to support closure (Item D.3). However, Item D.1, contains the following subsections:

None of these items exactly matches the Permittees' proposed change, although "Item D.1.e." most closely resembles changing the PCS from Option D to the WPC. It is based on this difference that the PMR "is not explicitly listed in 20.4.1.900 NMAC (incorporating Appendix I of 40 CFR §270.42)" and the cause for requesting a determination by the Secretary that the modification should be reviewed and approved as a Class 2 modification in accordance with 20.4.1.900 NMAC (incorporating 40 CFR §270.42(d)(1)).

The Permittees' basis for requesting the Class 2 determination is that the *reason or need for the PMR are compelling* and with the requirement to close Panel 1 rapidly approaching, perhaps as early as January 2003, the approval of WPC is required *in a timely manner*. The following information is provided to support the request for the Class 2 determination. The regulations at 20.4.1.900 NMAC (incorporating 40 CFR §270.42(d)(2)) state that, "...the Secretary shall consider the similarity of the modification to other modifications codified in Appendix I and the following criteria:...

- (ii) Class 2 modifications apply to changes that are necessary to enable a permittee to respond, in a timely manner, to,...
- (iii) Class 3 modifications substantially alter the facility or its operation." (Emphasis added)

Similarity to Other Modifications Codified in Appendix I

As described above, the difference between this PMR and other changes described in Appendix I, "Item D.1. Changes to the closure plan," is one of timing, i.e., that we are not seeking this modification as a result of an unexpected event during closure. The important fact relative to this comparison is that none of the changes under Item D.1. are Class 3's, they are all either Class 1's requiring prior approval or Class 2's. Based on this comparison the Permittees have concluded that review and approval as a Class 2 is appropriate. This conclusion is consistent with the reasoned arguments presented below for applying the "criteria" of 20.4.1.900 NMAC (incorporating 40 CFR §270.42(d)(2)(ii) and (iii)).

Criteria Describing Classification of Modifications

The General Approach to Defining Class 2 Permit Modifications in the Proposed Rule [52 FR 35838] and the Final Rule [53 FR 37912] *Permit Modifications for Hazardous Waste Management Facilities*, state that overall, Class 2 modifications *do not substantially alter the conditions of a permit or reduce protection of human health or the environment.* The changes requested in this PMR do not change the performance standards, the environmental standards, or the final closure system. Below is a discussion of the criteria pertaining to making Class 2 determinations provided by the EPA in the aforementioned Federal Registers and their relationship to this proposed PMR.

¹ Class 1 modifications requiring prior agency approval.

Class 2 modifications do not substantially alter the conditions of the permit. The WIPP HWFP conditions establishes the environmental and closure performance standards applicable to the PCS. This PMR does not alter or impact compliance with those established permit conditions. Note that as indicated in the attached Regulatory Crosswalk referenced in number 4 below only five regulatory requirements and only two HWFP sections are impacted by this PMR. This demonstrates the simple nature of the change and further supports the Class 2 determination.

Class 2 modifications do not reduce protection of human health or the environment. As indicated above the WIPP HWFP establishes the environmental and closure performance standards to ensure protection of human health and the environment. The proposed revised WPC will meet the HWFP environmental performance standards listed in the HWFP (Table IV.F.2.c) including, but not limited to **being two orders of magnitude below** the restriction of VOC migration at the E300 monitoring point and performing during a postulated methane explosion (Attachment I, Section I-1e(1)) for the operational life of the facility.

Class 2 modifications entail limited risks. The risks associated with this modification are limited and are no greater than those associated with Option D. In fact, risks associated with the revised closure plan are less than those in Option D, because of the simplicity of the installation and the reduction in man-hours that it would take to implement.

Class 2 modifications will frequently improve operations at the facility, leading to more efficient handling and treatment of the nation's hazardous waste. The WPC has been demonstrated to be less impactive to facility operations at WIPP.

The changes proposed to the panel closure in the PMR are in the panel closure configuration only, and do not substantially change any of the conditions of closure or of the permit. The changes leave in place the HWFP conditions which provide for protection of human health and the environment in accordance with standards for Miscellaneous Units provided at 40 CFR §264.601.

The last consideration discussed relates to the requirement for the Secretary to consider the similarity of the PMR to the criteria of 20.4.1.900 NMAC (incorporating 40 CFR §270.42(d)(iii)), which states that Class 3 modifications involve *substantially altering the facility or its operation*. In examining this requirement the Permittees make reference of the definition of "closure" found at 20.4.1.900 NMAC (incorporating 40 CFR §270.2),

"Closure means the act of securing a Hazardous Waste Management facility pursuant to the requirements of 40 CFR Part 264."

And 20.4.1.100 NMAC (incorporating 40 CFR §260.10),

"Partial closure means the closure of a hazardous waste management unit in accordance with the applicable requirements of Parts 264 and 265 of this chapter at a facility that contains other active hazardous waste management units. For example..."

The relevant points are that the WPC is a partial closure and closure is an act of securing units/facilities. The WPC does not "substantially alter the facility or its operation," it "secures" the unit/waste.

4. 20.4.1.900 NMAC (incorporating 40 CFR §270.42), requires the applicant to provide the applicable information required by 40 CFR §§270.13 through 270.22, 270.62, 270.63, and 270.66.

The regulatory crosswalk describes those portions of the WIPP HWFP that are affected by this PMR. Where applicable, regulatory citations in this modification reference Title 20, Chapter 4, Part 1, NMAC, revised June 14, 2000, incorporating the CFR, Title 40 (40 CFR Parts 264 and 270). 40 CFR §§270.16 through 270.22, 270.62, 270.63 and 270.66 are not applicable at WIPP. Consequently, they are not listed in the regulatory crosswalk table. 40 CFR §270.23 is applicable to the WIPP Hazardous Waste Disposal Units (HWDUs).

5. 20.4.1.900 NMAC (incorporating 40 CFR §270.11(d)(1) and 40 CFR §270.30(k)), requires any person signing under paragraph a and b must certify the document in accordance with 20.4.1.900 NMAC.

The transmittal letter for this PMR contains the signed certification statement in accordance with Permit Condition I.F of the WIPP HWFP.

Regulatory Crosswalk

Regulatory Citation(s) 20.4.1.900 NMAC	Regulatory Citation(s) 20.4.1.500 NMAC	Description of Requirement	Added or Clarified Information		
(incorporating 40 CFR Part 270)	(incorporating 40 CFR Part 264)		Section of the HWFP or Permit Application	Yes	No
§270.13		Contents of Part A permit application	Attachment O, Part A		Т
§270.14(b)(1)		General facility description	Attachment A		Т
§270.14(b)(2)	§264.13(a)	Chemical and physical analyses	Attachment B		T
§270.14(b)(3)	§264.13(b)	Development and implementation of waste analysis plan	Attachment B		Т
	§264.13(c)	Off-site waste analysis requirements	Attachment B		Т
§270.14(b)(4)	§264.14(a-c)	Security procedures and equipment	Attachment C		Т
§270.14(b)(5)	§264.15(a-d)	General inspection requirements	Attachment D		Т
	§264.174	Container inspections	Attachment D		Т
§270.23(a)(2)	§264.602	Miscellaneous units inspections	Attachment D		Т
§270.14(b)(6)		Request for waiver from preparedness and prevention requirements of Part 264 Subpart C	NA		
§270.14(b)(7)	264 Subpart D	Contingency plan requirements	Attachment F		Т
	§264.51	Contingency plan design and implementation	Attachment F		Т
	§264.52 (a) & (c-f)	Contingency plan content	Attachment F		Т
	§264.53	Contingency plan copies	Attachment F		Т
	§264.54	Contingency plan amendment	Attachment F		Т
	§264.55	Emergency coordinator	Attachment F		Т
	§264.56	Emergency procedures	Attachment F		Т
§270.14(b)(8)		Description of procedures, structures or equipment for:	Attachment E		Т
§270.14(b)(8)(i)		Prevention of hazards in unloading operations (e.g., ramps and special forklifts)	Attachment E		Т
§270.14(b)(8)(ii)		Runoff or flood prevention (e.g., berms, trenches, and dikes)	Attachment E		Т
§270.14(b)(8)(iii)		Prevention of contamination of water supplies	Attachment E		Т

Regulatory Citation(s) 20.4.1.900 NMAC	Regulatory Citation(s) 20.4.1.500		Added or Clarified Information		
(incorporating 40 CFR Part 270)	NMAC (incorporating 40 CFR Part 264)		Section of the HWFP or Permit Application	Yes	No
§270.14(b)(8)(iv)		Mitigation of effects of equipment failure and power outages	Attachment E		Т
§270.14(b)(8)(v)		Prevention of undue exposure of personnel (e.g., personal protective equipment)	Attachment E		Т
§270.14(b)(8)(vi) §270.23(a)(2)	§264.601	Prevention of releases to the atmosphere	Module II Module IV Attachment M2 Attachment N		Т
	264 Subpart C	Preparedness and Prevention	Attachment E		Т
	§264.31	Design and operation of facility	Attachment E		Т
	§264.32	Required equipment	Attachment E Attachment F		Т
	§264.33	Testing and maintenance of equipment	Attachment D		Т
	§264.34	Access to communication/alarm system	Attachment E		Т
	§264.35	Required aisle space	Attachment E		Т
	§264.37	Arrangements with local authorities	Attachment F		Т
§270.14(b)(9)	§264.17(a-c)	Prevention of accidental ignition or reaction of ignitable, reactive, or incompatible wastes	Attachment E		Т
§270.14(b)(10)		Traffic pattern, volume, and controls, for example: Identification of turn lanes Identification of traffic/stacking lanes, if appropriate Description of access road surface Description of access road load-bearing capacity Identification of traffic controls	Attachment G		Т
§270.14(b)(11)(i) and (ii)	§264.18(a)	Seismic standard applicability and requirements	Part B, Rev. 6 Chapter B		Т
§270.14(b)(11)(iii-v)	§264.18(b)	100-year floodplain standard	Part B, Rev. 6 Chapter B		Т
	§264.18(c)	Other location standards	Part B, Rev. 6 Chapter B		Т
§270.14(b)(12)	§264.16(a-e)	Personnel training program	Attachment H		Т
§270.14(b)(13)	264 Subpart G	Closure and post-closure plans	Attachment I & J	Т	

Regulatory Citation(s) 20.4.1.900 NMAC	Regulatory Citation(s) 20.4.1.500		Added or Clarifi	ied Infor	mation
(incorporating 40 CFR Part 270)	NMAC (incorporating 40 CFR Part 264)	Description of Requirement	Section of the HWFP or Permit Application	Yes	No
§270.14(b)(13)	§264.111	Closure performance standard	Attachment I		Т
§270.14(b)(13)	§264.112(a)(b)	Written content of closure plan	Attachment I	Т	
§270.14(b)(13)	§264.112(c)	Amendment of closure plan	Attachment I		Т
§270.14(b)(13)	§264.112(d)	Notification of partial and final closure	Attachment I		Т
§270.14(b)(13)	§264.112(e)	Removal of wastes and decontamination/dismantling of equipment	Attachment I		Т
§270.14(b)(13)	§264.113	Time allowed for closure	Attachment I	Т	
§270.14(b)(13)	§264.114	Disposal/decontamination	Attachment I		Т
§270.14(b)(13)	§264.115	Certification of closure	Attachment I		Т
§270.14(b)(13)	§264.116	Survey plat	Attachment I		Т
§270.14(b)(13)	§264.117	Post-closure care and use of property	Attachment J		Т
§270.14(b)(13)	§264.118	Post-closure plan; amendment of plan	Attachment J		Т
§270.14(b)(13)	§264.178	Closure/containers	Attachment I		Т
§270.14(b)(13)	§264.601	Environmental performance standards-Miscellaneous units	Attachment I		Т
§270.14(b)(13)	§264.603	Post-closure care	Attachment I		Т
§270.14(b)(14)	§264.119	Post-closure notices	Attachment J		Т
§270.14(b)(15)	§264.142	Closure cost estimate	NA		Т
	§264.143	Financial assurance	NA		Т
§270.14(b)(16)	§264.144	Post-closure cost estimate	NA		Т
	§264.145	Post-closure care financial assurance	NA		Т
§270.14(b)(17)	§264.147	Liability insurance	NA		Т
§270.14(b)(18)	§264.149-150	Proof of financial coverage	NA		Т
§270.14(b)(19)(i), (vi),(vii), and (x)		Topographic map requirements Map scale and date Map orientation Legal boundaries Buildings Treatment, storage, and disposal operations Run-on/run-off control systems Fire control facilities	Attachment O Part A Part B, Rev. 6 Chapter B, E		Т

Regulatory Citation(s) 20.4.1.900 NMAC	Regulatory Citation(s) 20.4.1.500	Description of Requirement –	Added or Clarified Information		
(incorporating 40 CFR Part 270) (incorporating 40 CFR Part 264)	Description of Requirement	Section of the HWFP or Permit Application	Yes	No	
§270.14(b)(19)(ii)	§264.18(b)	100-year floodplain	Attachment O Part A Part B, Rev. 6 Chapter B, E		Т
§270.14(b)(19)(iii)		Surface waters	Attachment O Part A Part B, Rev. 6 Chapter B, E		Т
§270.14(b)(19)(iv)		Surrounding Land use	Attachment O Part A Part B, Rev. 6 Chapter B, E		Т
§270.14(b)(19)(v)		Wind rose	Attachment O Part A Part B, Rev. 6 Chapter B, E		Т
§270.14(b)(19)(viii)	§264.14(b)	Access controls	Attachment O Part A Part B, Rev. 6 Chapter B, E, F		Т
§270.14(b)(19)(ix)		Injection and withdrawal wells	Attachment O Part A Part B, Rev. 6 Chapter B, E, F		Т
§270.14(b)(19)(xi)		Drainage on flood control barriers	Part B, Rev. 6 Chapter B, E, F		Т
§270.14(b)(19)(xii)		Location of operational units	Part B, Rev. 6 Chapter B		Т
§270.14(b)(20)		Other federal laws Wild and Scenic Rivers Act National Historic Preservation Act Endangered Species Act Coastal Zone Management Act Fish and Wildlife Coordination Act Executive Orders	Part B, Rev. 6 Chapter K		Т
§270.15	§264 Subpart I	Containers	Attachment M1		Т
	§264.171	Condition of containers	Attachment M1		Т
	§264.172	Compatibility of waste with containers	Attachment M1		Т
	§264.173	Management of containers	Attachment M1		Т
	§264.174	Inspections	Attachment D Attachment M1		Т
§270.15(a)	§264.175	Containment systems	Attachment M1		Т

Regulatory Citation(s) 20.4.1.900 NMAC (incorporating 40 CFR Part 270) Regulatory Citation(s) 20.4.1.500 NMAC (incorporating 40 CFR Part 264)	Citation(s) 20.4.1.500	Description of Requirement	Added or Clarified Information		
		Section of the HWFP or Permit Application	Yes	No	
§270.15(c)	§264.176	Special requirements for ignitable or reactive waste	Attachment E Permit Module II		Т
§270.15(d)	§264.177	Special requirements for incompatible wastes	Attachment E Permit Module II		Т
	§264.178	Closure	Attachment I		Т
§270.15(e)	§264.179	Air emission standards	Attachment E Attachment N		Т
§270.23	264 Subpart X	Miscellaneous units	Attachment M2	Т	
§270.23(a)	§264.601	Detailed unit description	Attachment M2	Т	
§270.23(b)	§264.601	Hydrologic, geologic, and meteorologic assessments	Permit Module IV Attachment M2		Т
§270.23(c)	§264.601	Potential exposure pathways	Permit Module IV Attachment M2 Attachment N		Т
§270.23(d)		Demonstration of treatment effectiveness	Permit Module IV Attachment M2 Attachment N		Т
	§264.602	Monitoring, analysis, inspection, response, reporting, and corrective action	Permit Module IV Attachment M2 Attachment N		Т
	§264.603	Post-closure care	Attachment J Attachment J1		Т
	264 Subpart E	Manifest system, record keeping, and reporting	Permit Module I Permit Module II Permit Module IV Attachment B		Т

ATTACHMENT A TABLE OF CHANGES

Reference	Explanation for Change		
Permit Attachment I, Table of Contents	Table of Contents updated to reflect current pagination.		
Permit Attachment I, List of Tables	List of Tables updated to add new Table I-1a.		
Permit Attachment I, List of Figures	The List of Figures is updated to reflect the WPC.		
Permit Attachment I, General	Change reflects current organization. (changes "Carlsbad Area Office" to "Carlsbad Field Office").		
Permit Attachment I, Section I-1c	The maximum waste inventory information was changed to reflect HWFP requirements in Module IV.		
Permit Attachment I, Section I-1d(1)	Reference is made to new Table I-1a, Panel Closure Schedule. This table is added to provide additional closure detail. Text was updated to address changes in the Panel Closure schedules and revised throughput estimates.		
Permit Attachment I, Section I- 1e(1)	This change achieves consistency regarding VOC emission limits from a closed panel and the point of compliance. This change makes the HWFP Module IV, and Attachments I, and M2, consistent.		
	Text was changed to refer to the Design Report for the Revised WPC at the Waste Isolation Pilot Plant.		
	Reference to proposed Attachment I1 is made with regard to the source term used for VOC calculations. The sources of information for actual VOCs headspace concentrations (Appendix A) include Table A-2 of DOE (1996a), and the WIPP Waste Information System Headspace Gas Concentration Report (2002). The maximum values for actual mass concentrations from the two sources of information are used in the analysis discussed in revised Attachment I1.		
	Updates Closure Plan to reflect proposed WPC.		
	Language was revised to be consistent with the regulatory intent of 20.4.1.500 NMAC (incorporating 40 CFR §264.112(c)) relevant to amendment of a closure plan.		
Permit Attachment I, Reference	The Design Report for the Revised Panel Closure System at the Waste Isolation Pilot Plant, Rev 1, October 2002 is added as a reference in the closure plan.		
Permit Attachment I, Table I-1	Table I-1 anticipated closure dates are being updated to reflect August, 2002 waste disposal throughput estimates and to reflect the time allowed for the WPC. Notes are updated/added to explain Table entries.		

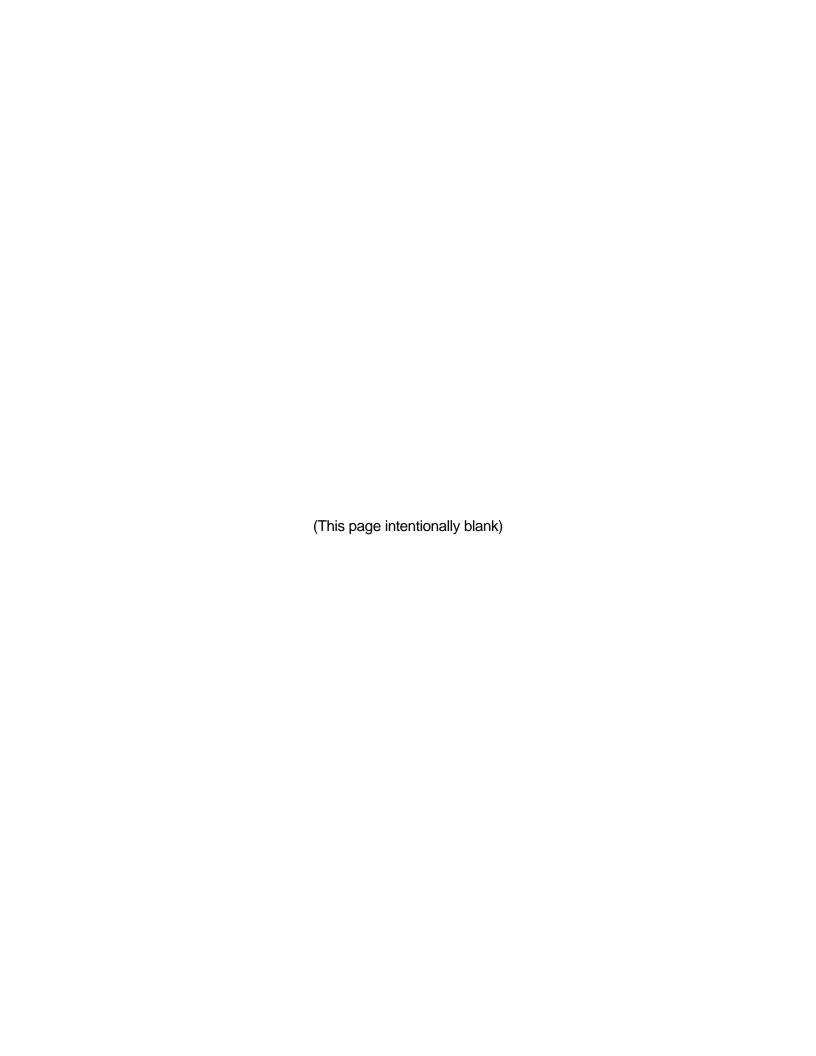
Reference	Explanation for Change
Permit Attachment I, Table I-1a and Figure I-2	A new schedule Table I-1a detailing the number of days for each panel closure activity has been inserted and Figure 1-2 is updated to reflect the schedule for WPC installation.
Permit Attachment I, Figure I-4	This Figure is being replaced with Figure 2-1 from the design report.
Attachment I1, Attachment I1 Appendix G, and Attachment I1 Appendix H	The Design Report for the Revised Panel Closure System at the Waste Isolation Pilot Plant, Rev 1, October 2002 (which includes WPC technical specifications and design drawings) is proposed for inclusion as Attachment I1. This will result in deletion of the current Attachment I1, Attachment I1 Appendix G and Attachment I1 Appendix H from the Permit, and the information in those attachments will be found in the revised Attachment I1.
Attachment M2, Section M2-2b	Added reference to the closure plan for pertinent panel closure information and eliminated information that is associated with the closure plan and Module IV.

ATTACHMENT B

PROPOSED CHANGES TO PERMIT ATTACHMENT I

Notes: Attachment I is included in its entirety due to the number of changes. Changes to Attachment I are described in Attachment A of this Permit Modification Request, Table of Changes.

ATTACHMENT I CLOSURE PLAN



ATTACHMENT I

CLOSURE PLAN

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ATTACHMENT I

CLOSURE PLAN

Introduction

This Permit Attachment contains the Closure Plan that describes the activities necessary to close the Waste Isolation Pilot Plant (WIPP) individual units and facility. Since the current plans for operations extend over several decades, the Permittees will periodically reapply for an operating permit in accordance with Title 20 of the New Mexico Administrative Code, Chapter 4, Part 1 (20.4.1 NMAC), Subpart 900 (incorporating 40 CFR §270.10(h)). Consequently, this Closure Plan describes several types of closures. The first type is Panel closure, which occurs as underground hazardous waste disposal units (HWDUs) are filled. Final closure at the end of the Disposal Phase will entail "clean" closure of the two storage units on the surface and construction of the four shaft seal systems. Finally, in the event a new permit is not issued prior to expiration of an existing permit, a modification to this Closure Plan will be sought to perform contingency closure. Contingency closure defers the final closure of waste management facilities such as the Waste Handling Building Container Storage Unit (WHB Unit), the conveyances, the shafts, and the haulage ways, because these will be needed to continue operations with non-mixed Transuranic (TRU) waste.

The hazardous waste management units (**HWMUs**) addressed in this Closure Plan include the aboveground HWMU in the WHB; and the parking area HWMU, and Panels 1 through 8, each consisting of seven rooms. In addition, the disposal area access drifts shown as E-300, E-140, W-30, and W-170 between S-1600 and S-3650 on Figure I-1 may, at some time in the future, be needed for waste disposal. These access drifts, if used for disposal, are also subject to this Closure Plan.

This plan was submitted to the New Mexico Environment Department (**NMED**) and the U.S. Environmental Protection Agency (**EPA**) in accordance with 20.4.1.900 NMAC (incorporating 40 CFR §270.14(b)(13)). Closure at the panel level will include the construction of barriers to limit the emission of hazardous waste constituents from the panel into the mine ventilation air stream below levels that meet environmental performance standards¹ and to mitigate the impacts of methane buildup and deflagration that may be postulated for some closed panels. The Post-Closure Plan (Permit Attachment J) includes the implementation of institutional controls to limit access and groundwater monitoring to assess disposal system performance. Until final closure is complete and has been certified in accordance with 20.4.1.500 NMAC (incorporating 40 CFR

¹ The mechanism for air emissions prior to closure is different than the mechanism after closure. Prior to closure, volatile organic compounds (VOC) will diffuse through drum filters based on the concentration gradient between the disposal room and the drum headspace. These VOCs are swept away by the ventilation system, thereby maintaining a concentration gradient that is assumed to be constant. Hence, the VOCs in the ventilation stream are a function of the number of containers only. After closure, the panel air will reach an equilibrium concentration with the drum headspace and no more diffusion will occur. The only mechanism for release into the mine ventilation system is due to pressure that builds up in the closed panel. This pressure arises from the creep closure mechanism that is reducing the volume of the rooms and from the postulated generation of gas as the result of microbial degradation of organic matter in the waste. Consequently, the emissions after panel closure are a direct function of pressurization processes and rates within the panel.

§264.115), a copy of the approved Closure Plan and all approved revisions will be on file at the WIPP facility and will be available to the Secretary of the NMED or the EPA Region VI Administrator upon request.

I-1 Closure Plan

This Closure Plan is prepared in accordance with the requirements of 20.4.1.500 NMAC (incorporating 40 CFR §264 Subparts G, I, and X), Closure and Post-Closure, Use and Management of Containers, and Miscellaneous Units. The WIPP underground HWDUs, including Panels 1 through 8 and the disposal area access drifts, designated as Panels 9 and 10 on Figure I-1, will be closed to meet the performance standards in 20.4.1.500 NMAC (incorporating 40 CFR §264.601). The WIPP surface facilities, including Waste Handling Building Container Storage Unit and the Parking Area Container Storage Unit, will be closed in accordance with 20.4.1.500 NMAC (incorporating 40 CFR §264.178). For final facility closure, this plan also includes closure and sealing of the facility shafts in accordance with 20.4.1.500 NMAC (incorporating 40 CFR §264.601).

Following completion of waste emplacement in each underground HWDU, the HWDU will be closed. The Permittees will notify the NMED of the closure of each underground HWDU as specified in the schedule in Figure I-2. For the purpose of this Closure Plan, panel closure is defined as the process of rendering underground HWDUs in the repository inactive and closed according to the facility Closure Plan. The Post-Closure Plan (Permit Attachment J) addresses requirements for future monitoring that are deemed necessary for the post-closure period, including monitoring closed panels prior to final facility closure.

For the purposes of this Closure Plan, final facility closure is defined as closure that will occur when all waste disposal areas are filled or when the WIPP achieves its capacity of 6.2 million cubic feet (ft³) (175,600 cubic meters (m³)) of TRU waste. At final facility closure, the surface container storage areas will be closed and equipment that can be decontaminated and used at other facilities will be cleaned and sent off site. Equipment that cannot be decontaminated plus any derived waste resulting from decontamination will be placed in the last open underground HWDU. Stockpiled salt may be placed in the underground; it may be used as the core material for the berm component of the permanent marker system; or it must be otherwise disposed of in accordance with Sections 2 and 3 of the Minerals Act of 1947 (30 U.S.C. §§602 and 603). In addition, shafts and boreholes which lie within the WIPP Site Boundary and penetrate the Salado will be plugged and sealed, and surface and subsurface facilities and equipment will be decontaminated and removed. Final facility closure will be completed to demonstrate compliance with the Closure Performance Standards contained in 20.4.1.500 NMAC (incorporating 40 CFR §264.111, 178, and 601).

In the event the Permittees fail to obtain an extension of the hazardous waste permit in accordance with 20.4.1.900 NMAC (incorporating 40 CFR §270.51) or fail to obtain a new permit in accordance with 20.4.1.900 NMAC (incorporating 40 CFR §270.10(h)) the Permittees will seek a modification to this Closure Plan in accordance with 20.4.1.900 NMAC (incorporating 40 CFR 270.42) to accommodate a contingency closure. Under contingency closure, storage units will undergo clean closure in accordance with 20.4.1.500 NMAC (incorporating 40 CFR §264.178) waste handling equipment, shafts, and haulage ways will be inspected for hazardous waste

residues (using, among other techniques, radiological surveys to indicate potential hazardous waste releases as described in Permit Attachment I3) and decontaminated as necessary, and underground HWDUs that contain radioactive mixed waste will be closed in accordance with the panel closure design described in this Closure Plan. Final facility closure, however, will be redefined and a request for a time extension for final closure will be requested.

A copy of this Closure Plan will be maintained by the Permittees at the WIPP facility and at the Department of Energy (**DOE**) Carlsbad Area Field Office. The primary contact person at the WIPP facility is:

Manager, Carlsbad Area Field Office U.S. Department of Energy Waste Isolation Pilot Plant P. O. Box 3090 Carlsbad, New Mexico 88221-3090 (505) 234-7300

I-1a Closure Performance Standard

The closure performance standard specified in 20.4.1.500 NMAC (incorporating 40 CFR §264.111), states that the closure shall be performed in a manner that minimizes the need for further maintenance; that minimizes, controls, or eliminates the escape of hazardous waste; and that conforms to the closure requirements of §264.178 and §264.601. These standards are discussed in the following paragraphs.

I-1a(1) Container Storage Units

Closure of the permitted container storage units (the Waste Handling Building Unit and Parking Area Unit) will be accomplished by removing all waste and waste residues. Indication of waste contamination will be based, among other techniques, on the use of radiological surveys as described in Permit Attachment I3. Radiological surveys use very sensitive radiation detection equipment to indicate if there has been a potential release of TRU mixed waste, including hazardous waste components, from a container. This allows the Permittees to indicate potential releases that are not detectable from visible evidence such as stains or discoloration. Visual inspection and operating records will also be used to identify areas where decontamination is necessary. Contaminated surfaces will be decontaminated until radioactivity is below free release limits². Once surfaces are determined to be free of radioactive waste constituents, they will be tested for hazardous waste contamination. These surface decontamination activities will ensure the removal of waste residues to levels protective of human health and the environment. The facility is expected to require no decontamination at closure because any waste spilled or released during operations will be contained and removed immediately. Solid waste management units associated described in Permit Module VII will be subject to closure. In the event portions of these units which require decontamination cannot be decontaminated, these portions will be removed and the resultant wastes will be managed as appropriately.

² The free release criteria for items, equipment, and areas is < 20 dpm/100 cm² for alpha radioactivity and < 200 dpm/100 cm² for beta-gamma radioactivity.

PERMIT ATTACHMENT I Page I-3 of 36 Once the container storage units are decontaminated and certified by the Permittees to be clean, no further maintenance is required. The facilities and equipment in these units will be reused for other purposes as needed.

I-1a(2) Miscellaneous Unit

Post-closure migration of hazardous waste or hazardous waste constituents to ground or surface waters or to the atmosphere, above levels that will harm human health or the environment, will not occur due to facility engineering and the geological isolation of the unit. The engineering aspects of closure are centered on the use of panel closures on each of the underground HWDUs and final facility seals placed in the shafts. The design of the panel closure system is based on the criteria that the closure system for closed underground HWDUs will prevent migration of hazardous waste constituents in the air pathway in concentrations above health-based levels beyond the WIPP land withdrawal boundary during the thirty-five (35) year operational and facility closure period and to withstand any flammable gas deflagration that may occur prior to final facility closure.

Consistent with the definitions in 20.4.1.101 NMAC (incorporating 40 CFR §260.10), the process of panel closure is considered partial closure because it is a process of rendering a part of the repository inactive and closed according to the approved underground HWDU partial closure plan. Panel closure will be complete when the panel closure system is emplaced and operational, when that underground HWDU and related equipment and structures have been decontaminated (if necessary), and when the NMED has been notified of the closure.

Shaft seals are designed to provide effective barriers to the inward migration of ground water and the outward migration of gas and contaminated brine over two discrete time periods. Several components become effective immediately and are expected to function for one hundred (100) years. Other components become effective more slowly, but provide permanent isolation of the waste. The final shaft seal design is specified in Permit Attachment I2.

The facility will be finally closed (i.e., decontaminated and decommissioned) to minimize the need for continued maintenance. Protection of human health and the environment includes, but is not limited to:

- Prevention of any releases that may have adverse effects on human health or the environment due to the migration of waste constituents in the groundwater or in the subsurface environment [20.4.1.500 NMAC, incorporating 40 CFR §264.601(a)].
- Prevention of any releases that may have adverse effects on human health or the environment due to migration of waste constituents in surface water, in wetlands, or on the soil surface [20.4.1.500 NMAC, incorporating 40 CFR §264.601(b)].
- Prevention of any release that may have adverse effects on human health or the environment due to migration of waste constituents in the air [20.4.1.500 NMAC, incorporating 40 CFR §264.601(c)].

As part of final facility closure, surface recontouring and reclamation will establish a stable vegetative cover, and further surface maintenance will not be necessary to protect human health and the environment. Prior to cessation of active controls, monuments will be emplaced to serve as long-term site markers to discourage activities that would penetrate the facility or impair the ability of the salt formation to isolate the waste from the surface environment for at least 10,000 years. The Federal government will maintain administrative responsibility for the repository site in perpetuity and will limit future use of the area.

If, during panel or final facility closure activities, unexpected events require modification of this Closure Plan to demonstrate compliance with closure performance standards, a Closure Plan amendment will be submitted in accordance with 20.4.1.900 NMAC (incorporating 40 CFR §270.42).

I-1a(4) Post-Closure Care

The post-closure care period will begin after completion of the first panel closure and will continue for thirty (30) years after final facility closure. The post-closure care period may be shortened or lengthened at the discretion of the regulatory agency based on evidence that human health and the environment are being protected or that they are at risk. During the post-closure period, the WIPP shall be maintained in a manner that complies with the environmental performance standards in 20.4.1.500 NMAC (incorporating 40 CFR §264.601). Post-closure activities are described in Permit Attachment J.

I-1b Requirements

The Permit specifies a sequential process for the closure of individual HWMUs at the WIPP. Each underground HWDU will undergo panel closure when waste emplacement in that panel is complete. Following waste emplacement in each underground HWDU, construction-side ventilation will be terminated and waste-disposal-side ventilation will be established in the next underground HWDU to be used, and the underground HWDU containing the waste will be closed. The Permittees will notify the NMED of the closure of each of the underground HWDUs as they are sequentially filled on a HWDU-by-HWDU basis. The HWMUs in the WHB and in the parking area will be closed as part of final facility closure of the WIPP facility.

The Permittees will notify the Secretary of the NMED in writing at least sixty (60) days prior to the date on which closure activities are scheduled to begin.

I-1c Maximum Waste Inventory

The WIPP will receive no more than 6.2 million ft³ (175,600 m³) of TRU mixed waste. Excavations are mined as permitted when needed during operations to maintain a reserve of disposal areas. The amount of waste placed in each room is limited by structural and physical considerations of equipment and design. Waste volumes include waste received from off-site generator locations as well as derived waste from disposal and decontamination operations. Maximum waste volumes in the disposal panels are calculated as follows: for 100 percent 55-gallon drums--11,502 7-packs consisting of 80,514 drums and 591,800 ft³ (16,760 m³) of waste; for 100 percent standard waste boxes (SWB)--11,580 SWBs and 767,750 ft³ (21,740 m³) of waste. The maximum waste volume in each disposal panel is approximately 86,500 55-gallon drum equivalents of CH waste or 636,000 ft³ (18,000 m³) as given in Module IV, Table IV.A.1 of the

<u>Permit.</u> Since the waste can arrive in any combination of 7-packs and SWBs, a fixed volume is not set for each panel. Furthermore, the placement of backfill materials to modify chemical nature of brines over the long-term will likely result in fewer containers per panel as described in Permit Attachment M2. For planning purposes, a maximum achievable volume is used. This equates to 662,400 ft³ (18,750 m³) of contact handled (**CH**) TRU per panel. 81,000 containers were assumed in design calculations since, for air dispersion modeling, it is important to maximize the number of container vents through which volatile organic compounds (**VOC**) may be released. In reality, using the 40 percent-60 percent mix, there would be only 51,000 containers in a panel, containing 56,000 vents (2 vents per SWB).

The maximum extent of operations during the term of this permit is expected to be Panels 1 through 4 and Panels 9 and 10, as shown on Figure I-1; the WHB Container Storage Unit; and the Parking Area Container Storage Unit. Note that panels 4, 9, and 10 are scheduled for excavation only under this permit. If other waste management units are permitted during the Disposal Phase, this Closure Plan will be revised to include the additional waste management units. At any given time during disposal operations, it is possible that two rooms may be receiving waste for disposal at the same time. Underground HWDUs in which disposal has been completed (i.e., in which CH TRU mixed waste emplacement activities have ceased) will undergo panel closure.

I-1d Schedule for Closure

For the purpose of establishing a schedule for closure, an operating and closure period of no more than thirty-five (35) years (twenty-five (25) years for disposal operations and ten (10) years for closure) is assumed. This operating period may be extended or shortened depending on a number of factors, including the rate of waste approved for shipment to the WIPP facility and the schedules of TRU mixed waste generator sites, and future decommissioning activities.

I-1d(1) Schedule for Panel Closure

The anticipated schedule for the closure of each of the underground HWDUs known as Panels 1 through 8 is shown in Figure I-2 and Table I-1a. This schedule assumes there will be little contamination within the exhaust drift of the panel. The following assumptions are made in estimating the time that closure will be initiated at each underground HWDU: waste operations are assumed to begin in July 1998 for planning purposes; throughput for CH waste is 784 drums per week (7 pallets per day, 4 days per week, 28 drums per pallet); and the capacity of a panel is 81,000 drums. Under these assumptions, a minimum of 104 weeks is needed to emplace a panel of the waste. Allowing a 25 percent contingency margin for maintenance delays and time to transition from one room to another, it is estimated that a panel will be filled 2.5 years after emplacement is initiated. The panel closure schedule reflects the anticipated closure dates for the underground HWDUs based on throughput estimates as of August 1, 2002. These dates are reflected in Table I-1. This means that underground HWDUs will be ready for closure according to the schedule in Table I-1. These dates are estimates for planning and permitting purposes. Actual dates may vary depending on the availability of waste from the generator sites. Waste availability at maximum throughput is not anticipated immediately as assumed here. Panel 1 closure will follow the schedule presented in Table I-1, and Table I-1a.

In the schedule in Figure I-2, notification of intent to close occurs thirty (30) days before placing the final waste in a panel. Once a panel is full, the Permittees will initially block ventilation through the panel as described in Permit Attachment M2 and then will assess the closure area for ground

conditions and contamination so that a definitive schedule and closure design can be determined. If as the result of this assessment the Permittees determine that a panel closure cannot be emplaced in accordance with the schedule in this Closure Plan, a modification will be submitted requesting an extension to the time for closure.

I-1d(2) Schedule for Final Facility Closure

The Disposal Phase for the WIPP facility is expected to require a period of twenty-five (25) years beginning with the first receipt of TRU waste at the WIPP facility and followed by a period ranging from seven to ten (7-10) years for decontamination, decommissioning, and final closure. Assuming the first waste receipt occurs in July 1998, the Disposal Phase may extend until 2023, and so the latest expected year of final closure of the WIPP facility (i.e., date of final closure certification) would be 2033. If, as is currently projected, the WIPP facility is dismantled at closure, all surface and subsurface facilities (except the hot cell portion of the WHB, which will remain as an artifact of the Permanent Marker System [PMS]) will be disassembled and either salvaged or disposed in accordance with applicable standards. In addition, asphalt and crushed caliche that was used for paving will be removed, and the area will be recontoured and revegetated in accordance with a land management plan. A detailed closure schedule will be submitted in writing to the Secretary of the NMED, along with the notification of closure. Throughout the closure period, all necessary steps will be taken to prevent threats to human health and the environment in compliance with all applicable Resource Conservation and Recovery Act (RCRA) permit requirements. Figure I-3 presents the best estimate of a final facility closure schedule.

The schedule for final facility closure is considered to be a best estimate because closure of the facility is driven by policies and practices established for the decontamination, if necessary, and decommissioning of radioactively contaminated facilities. These required activities include extensive radiological contamination surveys and hazardous constituent surveys using, among other techniques, radiological surveys to indicate potential hazardous waste releases. Both types of surveys will be performed at all areas of the WIPP site where hazardous waste were managed. These surveys, along with historical radiological survey records, will provide the basis for release of structures, equipment, and components for disposal or decontamination for release off site. Specifications will be developed for each structure to be removed. A cost benefit analysis will be needed to evaluate decontamination options if extensive decontamination is necessary. Individual equipment surveys, structure surveys, and debris surveys will be required prior to disposition. Size-reduction techniques may be required to dispose of mixed or radioactive waste at the WIPP site. Current DOE policy, as reflected in the WIPP facility Safety Analysis Report (SAR) (DOE 1997), requires the preparation of a final decommissioning and decontamination (D&D) plan immediately prior to final facility closure. In this way, the specific conditions of the facility at the time D&D is initiated will be addressed. Section I-1e(2) provides a more detailed discussion of final facility closure activities.

Figure I-3 shows the schedule for the final facility closure consisting of decontamination, as needed, of the TRU waste-handling equipment, and of the aboveground equipment and facilities, including closure of surface HWMUs; decontamination of the shaft and haulage ways; disposal of decontamination derived wastes in the last open underground HWDU; and subsequent closure of this underground HWDU. Subsequent activities will include installation of repository shaft seals.

An overall schedule for final facility closure, showing currently scheduled dates for the start and end of final facility closure activities is shown in Table I-2. The dates assume a start up date of March 1999 and hazardous waste permit effective dates of September 1999, September 2009, and September 2019. Details for panel closures are shown on Table I-1.

I-1d(3) Extension for Closure Time

As indicated by the closure schedule presented in Figure I-3, the activities necessary to perform facility closure of the WIPP facility will require more than one hundred eighty (180) days to complete because of additional stringent requirements for managing radioactive materials. Therefore, the Permit provides an extension of the 180-day final closure requirement in accordance with 20.4.1.500 NMAC (incorporating 40 CFR §264.113). During the extended closure period, the Permittees will continue to demonstrate compliance with applicable permit requirements and will take all steps necessary to prevent threats to human health and the environment as a result of TRU mixed waste management at the WIPP facility including all of the applicable measures in Permit Attachment E (Preparedness and Prevention).

In addition, according to the schedules in Figure I-3, the final derived wastes that are generated as the result of decontamination activities will not be disposed of for sixteen (16) months after the initiation of final facility closure. In accordance with 20.4.1.500 NMAC (incorporating 40 CFR §264.113(a)), the Permit provides an extension of the 90-day limit to dispose of final derived waste resulting from the closure process. This provision is necessitated by the fact that the radioactive nature of the derived waste makes placement in the WIPP the best disposition, and the removal of these wastes will, by necessity, take longer than ninety (90) days in accordance with the closure schedules. During this extended period of time, the Permittees will take all steps necessary to prevent threats to human health and the environment, including compliance with all applicable permit requirements. These steps include all of the applicable preparedness and prevention measures in Permit Attachment E.

Finally, in the event the hazardous waste permit is not renewed as assumed in the schedule, the Permittees will submit a modification to the Closure Plan to implement a contingency closure that will allow the Permittees to continue to operate for the disposal of non-mixed TRU waste. This modification will include a request for an extension of the time for final facility closure. This modified Closure Plan will be submitted to the NMED for approval.

I-1d(4) Amendment of the Closure Plan

If it becomes necessary to amend the Closure Plan for the WIPP facility, the Permittees will submit, in accordance with 20.4.1.900 NMAC (incorporating 40 CFR §270.42), a written notification of or request for a permit modification describing any change in operation or facility design that affects the Closure Plan. The written notification or request will include a copy of the amended Closure Plan for approval by the NMED. The Permittees will submit a written notification of or request for a permit modification to authorize a change in the approved plan, if:

- There are changes in operating plans or in the waste management unit facility design that affect the Closure Plan
- There is a change in the expected year of closure

- Unexpected events occur during panel or final facility closure that require modification of the approved Closure Plan
- Changes in State or Federal laws affect the Closure Plan
- Permittees fail to obtain permits for continued operations as discussed above

The Permittees will submit a written request for a permit modification with a copy of the amended Closure Plan at least sixty (60) days prior to the proposed change in facility design or operation or within sixty (60) days of the occurrence of an unexpected event that affects the Closure Plan. If the unexpected event occurs during final closure, the permit modification will be requested within thirty (30) days of the occurrence. If the Secretary of the NMED requests a modification of the Closure Plan, a plan modified in accordance with the request will be submitted within sixty (60) days of notification or within thirty (30) days, if the change in facility condition occurs during final closure.

I-1e Closure Activities

Closure activities include those instituted for panel closure (i.e., closure of filled underground HWDUs), contingency closure (i.e., closure of surface HWMUs and decontamination of other waste handling areas) and final facility closure (i.e., closure of surface HWMUs, D&D of surface facilities and the areas surrounding the WHB, and placement of repository shaft seals. Panel closure systems will be emplaced to separate areas of the facility and to isolate panels. Permit Attachments I1 and I2 provide panel closure system and shaft seal designs. All closure activities will meet the applicable quality assurance (QA)/quality control (QC) program standards in place at the WIPP facility. Facility monitoring procedures in place during operations will remain in place through final closure, as applicable.

I-1e(1) Panel Closure

Following completion of waste emplacement in each underground HWDU, disposal-side ventilation will be established in the next panel to be used, and the panel containing the waste will be closed. A panel closure system will be emplaced in the panel access drifts, in accordance with the design in Permit Attachment I1 and the schedules in Figure I-2, Table I-1, and Table I-1a. The panel closure system is designed to meets the following requirements that were established by the DOE for the design to comply with 20.4.1.500 NMAC (incorporating 40 CFR §264.601(a)):

- the panel closure system shall limit <u>VOC migration from a closed panel consistent</u> with the limits found in Table IV.F.2.c of the Permit. the migration of VOCs to the compliance point so that compliance is achieved by at least one order of magnitude
- the panel closure system shall consider potential flow of VOCs through the disturbed rock zone (**DRZ**) in addition to flow through closure components
- the panel closure system shall perform its intended functions under loads generated by creep closure of the tunnels

- the panel closure system shall perform its intended function under the conditions of a postulated methane explosion
- the nominal operational life of the closure system is thirty-five (35) years
- the panel closure system for each individual panel shall not require routine maintenance during its operational life
- the panel closure system shall address the most severe ground conditions expected in the waste disposal area
- the design class of the panel closure system shall be IIIb (which means that it is to be built to generally accepted national design and construction standards)
- the design and construction shall follow conventional mining practices
- structural analysis shall use data acquired from the WIPP underground
- materials shall be compatible with their emplacement environment and function
- treatment of surfaces in the closure areas shall be considered in the design
- thermal cracking of concrete shall be addressed
- during construction, a QA/QC program shall be established to verify material properties and construction practices
- construction of the panel closure system shall consider shaft and underground access and services for materials handling

The performance standard for air emissions from the WIPP facility is established in Module IV and Permit Attachment M2. Releases shall be below these limits for the facility to remain in compliance with standards to protect human health and the environment. The following panel closure design has been shown, through analysis, to meet these standards, if emplaced in accordance with the specifications in Permit Attachment I1.

The approved design for the panel closure system calls for a composite panel barrier system consisting of a rigid concrete plug with removal of the DRZ, and an explosion-isolation wall. The design basis for this closure is such that the migration of hazardous waste constituents from closed panels during the operational and closure period would result in concentrations well below health-based standards. The source term used as the design basis included the average concentrations of VOCs from CH waste containers as measured in headspace gases through January 1995 is addressed in Design Report for a Revised Panel Closure System at the Waste Isolation Pilot Plant, Rev. 1. The VOCs are assumed to have been released by diffusion through the container vents and are assumed to be in equilibrium with the air in the panel. Emissions from the closed panel occur at a rate determined by gas generation within the waste and creep closure of the panel.

Attachment I1 provides the design and material engineering specifications for the construction and emplacement of the panel closure system. The panel closure consists of two components: a concrete block explosion isolation wall and run of mine salt backfill. Attachment I1 shows pertinent design drawings and figures.

<u>The panel closure system complies with the design basis established for the panel closure system and meets the closure standards in 20.4.1.500 NMAC (incorporating 40 CFR §264.601).</u>

Figures I-4 and I-5 show a diagram of the panel closure design and installation envelopes. Permit Attachment I1 provides the detailed design and the design analysis for the panel closure system. Although the permit application proposed several panel closure design options, depending on the gas generated by wastes and the age of the mined openings, the NMED and EPA determined that only the most robust design option (D) would be approved. This The decision to select a design option does not prevent the Permittees from continuing to collect data on the behavior of the wastes and mined openings, or proposing a modification to the Closure Plan in the future, using the available data to support a request for reconsideration of a new one or more of the original design options. If a design different from Option D as defined in Permit Attachment I1 that defined in Permit Attachment I1 is proposed, the appropriate permit modification will be sought.

I-1e(2) Decontamination and Decommissioning

Decontamination is defined as those activities which are performed to remove contamination from surfaces and equipment that are not intended to be disposed of at the WIPP facility. The policy at the WIPP will be to decontaminate as many areas as possible, consistent with radiation protection policy. Decontamination is part of all closure activities and is a necessary activity in the clean closure of the surface container management units. Decontamination determinations are based upon radiological and hazardous constituent surveys.

Decommissioning is the process of removing equipment, facilities, or surface areas from further use and closing the facility. Decommissioning is part of final facility closure only and will involve the removal of equipment, buildings, closure of the shafts, and establishing active and passive institutional controls for the facility. Passive institutional controls are not included in the Permit.

The objective of D&D activities at the WIPP facility is to return the surface to as close to the preconstruction condition as reasonably possible, while protecting the health and safety of the public and the environment. Major activities required to accomplish this objective include, but are not limited to the following:

- 1. Review of operational records for historical information on releases
- 2. Visual examination of surface structures for evidence of spills or releases
- 3. Performance of site contamination surveys
- 4. Decontamination, if necessary, of usable equipment, materials, and structures including surface facilities and areas surrounding the WHB.

- Disposal of equipment/materials that cannot be decontaminated but that meet the treatment, storage, and disposal facility waste acceptance criteria (TSDF-WAC) in an underground HWDU
- 6. Emplacement of final panel closure system
- 7. Emplacement of shaft seals³
- 8. Regrading the surface to approximately original contours
- Initiation of active controls

This Closure Plan will be amended prior to the initiation of closure activities to specify the methods to be used.

Health and Safety

Before final closure activities begin, health physics personnel will conduct a hazards survey of the unit(s) being closed. A release of radionuclides could also indicate a release of hazardous constituents. If radionuclides are not detected, sampling for hazardous constituents will still be performed if there is documentation or visible evidence that a spill or release has occurred. The purpose of the hazards survey will be to identify potential contamination concerns that may present hazards to workers during the closure activities and to specify any control measures necessary to reduce worker risk. This survey will provide the information necessary for the health physics personnel to identify worker qualifications, personal protective equipment (**PPE**), safety awareness, work permits, exposure control programs, and emergency coordination that will be required to perform closure related activities.

I-1e(2)(a) Determine the Extent of Contamination

The first activities performed as part of decontamination include those needed to determine the extent of any contamination that needs to be removed prior to decommissioning a facility. This includes activities 1 to 3 above and, as can be seen by the schedules in Figures I-3 and I-4 (Items B and C), these surveys are anticipated to take ten (10) months to perform, including obtaining the results of any sample analyses. The process of identifying areas that require decontamination include three sources of information. First, operating records will be reviewed to determine where contamination has previously been found as the result of historical releases and spills. Even though releases and spills will have been cleaned up at the time of occurrence, newer equipment and technology may allow further cleaning. Second, surfaces of facilities and structures will be examined visually for evidence of spills or releases. Finally, extensive detailed contamination surveys will be performed to document the level of cleanliness for all surface structures and equipment. If equipment or areas are identified as contaminated, the Permittees will notify NMED as specified in Permit Module I, and a plan and procedure(s) will be developed and implemented to address decontamination-related questions, including:

• Should the component be decontaminated or disposed of as waste?

³ For the purposes of planning, the conclusion of shaft sealing is used by the DOE as the end of closure activities and the beginning of the Post-Closure Care Period.

- What is the most cost-effective method of decontaminating the component?
- Will the decontamination procedures adequately contain the contamination?

Radiological and hazardous constituent surveys will be used in determining the presence of hazardous waste and hazardous waste residues in areas where spills or releases have occurred. Radiological surveys are described in Permit Attachment I3. Once cleanup of the radioactivity has been completed, the surface will be sampled for hazardous constituents specified in Permit Attachment O to determine that they, too, have been cleaned up. Sampling and analysis protocols will be consistent with EPA's document SW-846 (EPA, 1996).

I-1e(2)(b) Decontamination Activities

Once the extent of contamination is known, decontamination activities will be planned and performed. Radiological control and the control of hazardous waste residues are the primary criteria used in the design of decontamination activities. Radiation control procedures require that careful planning and execution be used in decontamination activities to prevent the exposure of workers beyond applicable standards and to prevent the further spread of contamination. Careful control of entry, cleanup, and ventilation are vital components of radiation decontamination. The level of care mandated by DOE orders and occupational protection requirements results in closure activities that will exceed the one hundred eighty (180) days allowed in 20.4.1.500 NMAC (incorporating 40 CFR §264.113(b)). Decontamination activities are included as item 4 above and are shown on the schedules for contingency closure and final facility closure (Figures I-3 and I-4) as activities D, E, and F. These activities are anticipated to have a duration of twenty (20) months for both contingency closure and for final facility closure. The result of these activities is the clean closure of the surface container management units. Under contingency closure, the other areas that have been decontaminated will not be closed. Instead they will remain in use for continued waste management activities involving non-mixed waste. Under final facility closure, other areas that are decontaminated are eligible for closure.

The "Start Clean—Stay Clean" operating philosophy of the WIPP Project will provide for minimum need for decontamination. However, the need for decontamination techniques may arise.

Decontamination activities will be coordinated with closure activities so that areas that have been decontaminated will not be recontaminated. All waste resulting from decontamination activities will be surveyed and analyzed for the presence of radioactive contamination and hazardous constituents specified in Permit Attachment O. The waste will be characterized as hazardous, mixed, or radioactive and will be packaged and handled appropriately. Mixed and radioactive waste will be classified as TRU mixed waste managed in accordance with the applicable Permit requirements. Derived mixed waste collected during decontamination activities that are generated before repository shafts have been sealed will be emplaced in the facility, if appropriate, or will be managed together with decontamination derived waste collected after the underground is closed. This waste will be classified and shipped off site to an appropriate, permitted facility for treatment, if necessary, and for disposal.

Removal of Hazardous Waste Residues

Because of the type of waste management activities that will occur at the WIPP facility, waste residues that may be encountered during the operation of the facility and at closure may include

derived waste. Derived wastes result from the management of the waste containers or may be collected as part of the closure activities (such as those during which wipes were used to sample the containers and equipment for potential radioactive contamination or those involving solidified decontamination solutions, the handling of equipment designated for disposal, and the handling of residues collected as a result of spill cleanup). Derived wastes collected during the operation and closure of the WIPP facility will be identified and managed as TRU mixed wastes. These wastes will be disposed in the active underground HWDU. D&D derived wastes and equipment designated for disposal will be placed in the last underground HWDU panel before closure of that unit.

Surface Container Storage Units

The procedures employed for waste receipt at the WIPP facility minimize the likelihood for any waste spillage to occur outside the WHB. TRU mixed waste is shipped to the WIPP facility in approved shipping containers (e.g., TRUPACT-IIs) that are not opened until they are inside the WHB. Therefore, it is unlikely that soil in the Parking Area Unit or elsewhere in the vicinity of the WHB will become contaminated with TRU mixed waste constituents as a result of TRU mixed waste management activities. An evaluation of the soils in the vicinity of the WHB will only be necessary if a documented event resulting in a release has occurred outside the WHB.

The "Start Clean—Stay Clean" operating philosophy of the WIPP Project will minimize the need for decontamination of the WHB during decommissioning and closure. Procedures for opening shipping containers in the WHB limit the opportunity for waste spillage.

Should the need for decontamination of the WHB arise, the following methods may be employed, as appropriate, for the hazardous constituent/contaminant type and extent:

- Chemical cleaning (e.g., water, mild detergent cleanser, and polyvinyl alcohol)
- Nonchemical cleaning (e.g., sandblasting, grinding, high-pressure water spray, scabbler pistons and needle scalers, ice-blast technology, dry-ice blasting)
- Removal of contaminated components such as pipe and ductwork

Waste generated as a result of WHB decontamination activities will be managed as derived waste in accordance with applicable permit requirements and will be emplaced in the last open underground HWDU for disposal.

Waste Handling Equipment and

The waste hoist conveyance and associated waste handling equipment will be decontaminated to background or be disposed as derived waste as part of both contingency and final facility closure. Procedures for detection and sampling will be as described above. Equipment cleanup will be as above using chemical or nonchemical techniques.

Personnel Decontamination

PPE worn by personnel performing closure activities in areas determined to be contaminated will be disposed of appropriately. Disposable PPE used in such areas will be placed into containers

and managed as TRU mixed waste. Non-disposable PPE will be decontaminated, if possible. Non-disposable PPE that cannot be decontaminated will be managed as TRU mixed waste.

In accordance with DOE policy, TRU mixed waste PPE will be considered to be contaminated with all of the hazardous waste constituents contained in the containers that have been managed within the unit being closed. Wastes collected as a result of closure activities and that may be contaminated with radioactive and hazardous constituents will be considered TRU mixed wastes. These wastes will be managed as derived wastes, as described in Permit Attachment M2. Such waste, collected as the result of closure of the WIPP facility, will be disposed of in the final open underground HWDU.

Cleanup Criteria

Radiation decontamination will be less than or equal to the following levels, or to whatever lesser levels that may be established by DOE Order at the time of cleanup:

Contamination Type	<u>Loose</u> ⁴	Fixed plus removable
alpha contamination (a)	20 dpm/100 cm ²	500 dpm/100 cm ²
beta-gamma contamination (ß-?)	200 dpm/100 cm ²	1000 dpm/100 cm ²

Hazardous waste decontamination will be conducted in accordance with standards in 20.4.1.500 NMAC (incorporating 40 CFR §264) or as incorporated into the Permit.

Final Contamination Sampling and Quality Assurance

Verification samples will be analyzed by an approved laboratory that has been qualified by the DOE according to a written program with strict criteria. The QA requirements of EPA/SW-846, "Test Methods for Evaluating Solid Waste" (EPA, 1986), will be met for hazardous constituent sampling and analyses.

Quality Assurance/Quality Control

Because decisions about closure activities may be based, in part, on analyses of samples of potentially contaminated surfaces and media, a program to ensure reliability of analytical data is essential. Data reliability will be ensured by following a QA/QC program that mandates adequate precision and accuracy of laboratory analyses. Field documentation will be used to document the conditions under which each sample is collected. The documented QA/QC program in place at the WIPP facility will meet applicable RCRA QA requirements.

Field blanks and duplicate samples will be collected in the field to determine potential errors introduced in the data from sample collection and handling activities. To determine the potential for cross-contamination, rinsate blanks (consisting of rinsate from decontaminated sampling equipment) will be collected and analyzed. At least one rinsate blank will be collected for every 20 field samples. Duplicate samples will be collected at a frequency of one duplicate sample for

⁴ The unit "dpm" stands for "disintegration per minute" and is the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

every ten field samples. In no case will less than one rinsate blank or duplicate sample be collected for a field-sampling effort. These blank and duplicate samples will be identified and treated as separate samples. Acceptance criteria for QA/QC hazardous constituent sample analyses will adhere to the most recent version of EPA SW-846 or other applicable EPA guidance.

I-1e(2)(c) Dismantling

Final facility closure will include dismantling of structures on the surface and in the underground. These are items 6 and 7 above and are represented as Activity G in the final facility closure schedule in Figure I-4. During dismantling, priority will be given to contaminated structures and equipment that cannot be decontaminated to assure these are properly disposed of in the remaining open underground HWDU in a timely manner. All such facilities and equipment are expected to be removed and disposed of sixteen (16) months after the initiation of closure. Dismantling of the balance of the facility, including those structures and equipment that are not included in the application and are not used for TRU mixed waste management, is anticipated to take an additional sixty-six (66) months. It should be noted that the placement of D&D waste into the final underground HWDU may, by necessity, involve the placement of uncontainerized bulk materials such as concrete components, building framing, structural members, disassembled or partially disassembled equipment, or containerized materials in non-standard waste boxes. Such placement will only occur if it can be shown that it is protective of human health and the environment and all items are described in an amendment to the Closure Plan. Identification of bulk items is not possible at this time since their size and quantity will depend on the extent of non-removable contamination.

I-1e(2)(d) Closure of Open Underground HWDU

The closure of the final underground HWDU is shown by Activity H in Figure I-3. This closure will be consistent with the description in Section I-1e(1) and the design in Permit Attachment I5. Detailed closure schedules for underground HWDUs are given in Figure I-2 and Table I-1.

I-1e(2)(e) Final Facility Closure

Final facility closure includes several activities designed to assure both the short-term isolation of the waste and the long-term integrity of the disposal system. These include the placement of plugs in boreholes that penetrate the salt and the placement of the repository sealing system. In addition, the surface will be returned to as near its original condition as practicable, and will be readied for the construction of markers and monuments that will provide permanent marking of the repository location and contents.

Figure I-6 identifies where ten existing boreholes overlie the proximate area of the repository footprint. Of these identified boreholes in Figure I-6, all but ERDA-9 are terminated hundreds of feet above the repository horizon. Only ERDA-9, which is accounted for in long-term performance modeling, is drilled through the repository horizon, near the WIPP excavations.

To mitigate the potential for migration beyond the repository horizon, the DOE has specified that borehole seals be designed to limit the volume of water that could be introduced to the repository from the overlying water-bearing zones and to limit the volume of contaminated brine released from the repository to the surface or water-bearing zones.

Borehole plugging activities have been underway since the 1970s, from the early days of the development of the WIPP facility. Early in the exploratory phase of the project, a number of boreholes were sunk in Lea and Eddy counties. After the WIPP site was situated in its current location, an evaluation of all vertical penetrations was made by Christensen and Peterson (1981).

As an initial criterion, any borehole that connects a fluid-producing zone with the repository horizon becomes a plugging candidate.

Grout plugging procedures are routinely performed in standard oil-field operations; however, quantitative measurements of plug performance are rarely obtained. The Bell Canyon Test reported by Christensen and Peterson (1981) was a field test demonstration of the use of cementitious plugging materials and modification of existing industrial emplacement techniques to suit repository plugging requirements. Cement emplacement technology was found to be "generally adequate to satisfy repository plugging requirements." Christensen and Peterson (1981) also report "that grouts can be effective in sealing boreholes, if proper care is exercised in matching physical properties of the local rock with grout mixtures. Further, the reduction in fluid flow provided by even limited length plugs is far in excess of that required by bounding safety assessments for the WIPP." The governing regulations for plugging and/or abandonment of boreholes are summarized in Table I-3.

The proposed repository sealing system design will prevent water from entering the repository and will prevent gases or brines from migrating out of the repository. The proposed design includes the following subsystems and associated principal functions:

- Near-surface: to prevent subsidence at and around the shafts
- Rustler Formation: to prevent subsidence at and around the shafts and to ensure compliance with Federal and State of New Mexico groundwater protection requirements
- Salado Formation: to prevent transporting hazardous waste constituents beyond the point of compliance specified in Permit Module V

The repository sealing system will consist of natural and engineered barriers within the WIPP repository that will withstand forces expected to be present because of rock creep, hydraulic pressure, and probable collapses in the repository and will meet the closure requirements of 20.4.1.500 NMAC (incorporating 40 CFR §264.601 and §264.111). Permit Attachment I2 presents the final repository sealing system design.

Once shaft sealing is completed, the Permittees will consider closure complete and will provide the NMED with a certification of such within sixty (60) days.

I-1e(2)(f) Final Contouring and Revegetation

In the preparation of its Final Environmental Impact Statement (DOE, 1980), the DOE committed to restore the site to as near to its original condition as is practicable. This involves removal of access roads, unneeded utilities, fences, and any other structures built by the DOE to support WIPP operations. Provisions would be left for active post-closure controls of the site and for the installation of long-term markers and monuments for the purpose of permanently marking the location of the repository and waste. Permit Attachment J-1a(1) discusses the active and long-term controls proposed for the WIPP. Installation of borehole seals are anticipated to take twelve (12) months, shaft seals fifty-two (52) months, and final surface contouring eight (8) months.

I-1e(2)(g) Closure, Monuments, and Records

A record of the WIPP Project shall be listed in the public domain in accordance with the requirements of 20.4.1.500 NMAC (incorporating 40 CFR §264.116). Active access controls will be employed for at least the first one hundred (100) years after final facility closure. In addition, a passive control system consisting of monuments or markers will be erected at the site to inform future generations of the location of the WIPP repository (see "Permanent Marker Conceptual Design Report" [DOE, 1995b]).

This Permit requires only a thirty (30) year post-closure period. This is the maximum post-closure time frame allowed in an initial Permit for any facility, as specified in 20.4.1.500 NMAC (incorporating 40 CFR §264.117(a)). The Secretary of the NMED may shorten or extend the post-closure care period at any time in the future prior to completion of the original post-closure period (30 years after the completion of construction of the shaft seals). The Permanent Marker Conceptual Design Report and other provisions during the first 100 years after closure are addressed under another Federal regulatory program.

Closure of the WIPP facility will contribute to the following:

- Prevention of the intrusion of fluids into the repository by sealing the shafts
- Prevention of human intrusion after closure
- Minimization of future physical and environmental surveillance

Detailed records shall be filed with local, State, and Federal government agencies to ensure that the location of the WIPP facility is easily determined and that appropriate notifications and restrictions are given to anyone who applies to drill in the area. This information, together with land survey data, will be on record with the U.S. Geological Survey and other agencies. The Federal government will maintain permanent administrative authority over those aspects of land management assigned by law. Details of post-closure activities are in Permit Attachment J.

I-1e(3) Performance of the Closed Facility

20.4.1.500 NMAC (incorporating 40 CFR §264.601) requires that a miscellaneous unit be closed in a manner that protects human health and the environment. The RCRA Part B permit application addressed the expected performance of the closed facility during the thirty (30) year post closure period. Groundwater monitoring will provide information on the performance of the closed facility during the post-closure care period, as specified in Section J-1a(2) (Monitoring) of Permit Attachment J.

The principal barriers to the movement of hazardous constituents from the facility or the movement of waters into the facility are the halite of the Salado Formation (natural barrier) and the repository seals (engineered barrier). Data and calculations that support this discussion were presented in the permit application. The majority of the calculations performed for the repository are focused on long-term performance and making predictions of performance over 10,000 years. In the short term, the repository is reaching a steady state configuration where the hypothetical brine inflow rate is affected by the increasing pressure in the repository due to gas generation and creep closure. These three phenomena are related in the numerical modeling

performed to support the permit application. The modeling parameters, assumptions and methodology were described in detail in the permit application.

I-2 Notices Required for Disposal Facilities

I-2a Certification of Closure

Within sixty (60) days after completion of closure activities for a HWMU (i.e., for each storage unit and each disposal unit), the Permittees will submit to the Secretary of the NMED a certification that the unit (and, after completion of final closure, the facility) has been closed in accordance with the specifications of this Closure Plan. The certification will be signed by the Permittees and by an independent New Mexico registered professional engineer. Documentation supporting the independent registered engineer's certification will be furnished to the Secretary of the NMED with the certification.

I-2b Survey Plat

Within sixty (60) days of completion of closure activities for each underground HWDU, and no later than the submission of the certification of closure of each underground HWDU, the Permittees will submit to the Secretary of the NMED a survey plat indicating the location and dimensions of hazardous waste disposal units with respect to permanently surveyed benchmarks. The plat will be prepared and certified by a professional land surveyor and will contain a prominently displayed note that states the Permittees' obligation to restrict disturbance of the hazardous waste disposal unit. In addition, the land records in the Eddy County Courthouse, Carlsbad, New Mexico, will be updated through filing of the final survey plats.

References

Christensen, C. L., and Peterson, E. W. 1981. "Field-Test Programs of Borehole Plugs in Southeastern New Mexico." In The *Technology of High-Level Nuclear Waste Disposal Advances in the Science and Engineering of the Management of High-Level Nuclear Wastes*, P. L. Hofman and J. J. Breslin, eds., SAND79-1634C, DOE/TIC-4621, Vol. 1, pp. 354–369. Technical Information Center of the U.S. Department of Energy, Oak Ridge, TN.

DOE, see U.S. Department of Energy

EPA, see U.S. Environmental Protection Agency

RockSol Consulting Group, Inc., 2002, "Design Report for a Revised Panel Closure System at the Waste Isolation Pilot Plant," prepared for Westinghouse TRU Solutions, Rev. 1, October 2002.

- U.S. Department of Energy, 1980, "Final Environmental Impact Statement, Waste Isolation Pilot Plant," DOE/EIS 0026, U.S. Department of Energy, Washington, D.C.
- U.S. Department of Energy, 1995b, "Permanent Marker Conceptual Design Report," from Appendix PMR of the *Draft Compliance Certification Application*, Draft-DOE/CAO-2056, U.S. Department of Energy, Carlsbad, NM.
- U.S. Department of Energy, 1997, "WIPP Safety Analysis Report," DOE/WIPP-95-2065, Revision 1, U.S. Department of Energy, Carlsbad, NM.
- U.S. Environmental Protection Agency, 1996, "Test Methods for Evaluating Solid Waste," SW-846, U.S. Environmental Protection Agency, Washington, D.C.

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TABLES

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TABLE I-1 ANTICIPATED EARLIEST CLOSURE DATES FOR THE UNDERGROUND HWDUs

HWDU	OPERATIONS START	OPERATIONS END	CLOSURE START	CLOSURE END
PANEL 1	3/99	1/02 <u>1/03</u>	2/02 <u>2/03</u>	6/02 <u>6/04</u> See Note <u>43</u>
PANEL 2	1/02 <u>1/03</u>	7/04 <u>10/04</u>	8/04 <u>11/04</u>	12/05 <u>3/06</u>
PANEL 3	7/04 <u>10/04</u>	1/07 <u>1/06</u>	2/07 <u>2/06</u>	6/07
PANEL 4	1/07 <u>9/05</u>	7/09 <u>12/07</u>	8/09 <u>1/08</u>	12/10 <u>5/09</u>
PANEL 5	7/09 <u>4/07</u>	1/12 <u>6/10</u>	2/12 <u>7/10</u>	6/12 <u>11/11</u>
PANEL 6	1/12 <u>10/09</u>	7/14 <u>2/13</u>	8/14 <u>3/13</u>	12/15 <u>7/14</u>
PANEL 7	7/14 <u>5/12</u>	1/17 <u>9/15</u>	2/17 <u>10/15</u>	6/17 <u>2/17</u>
PANEL 8	1/17	7/19	8/19	12/20
PANEL 9	7/19	1/22	2/22	SEE NOTE 4
PANEL 10	1/22	7/24	8/24	SEE NOTE 4

NOTE 1: Only Panels 1 to 3 will be closed under the permit covered by this application. Closure schedules for Panels 4 through 10 are projected assuming new permits will be issued in 2009 and 2019. Panel 8, 9, and 10 dates will be proposed (updated) in future permit modification requests.

NOTE 2: The point of closure start is defined as sixty (60) days following notification to the NMED of closure.

NOTE 3: The point of closure end is defined as one hundred eighty (180) four hundred sixty seven (467) days following placement of final waste in the panel.

NOTE 4: The time to close these areas may be extended depending on the nature and extent of the disturbed rock zone. The excavations that constitute these panels will have been opened for as many as forty (40) years so that the preparation for closure may take longer than the time allotted in Figure I-2 and Table I-1a. If this extension is needed, it will be requested as an amendment to the Closure Plan.

TABLE I-1a PANEL CLOSURE SCHEDULE

<u>ACTIVITY</u>		<u>DURATION</u>
Notify NMED	<u>-30 days</u>	
Last receipt of waste	<u>0 days</u>	
Perform Radiation Survey	<u>0 days</u>	<u>day 000 to day 30*</u>
Prepare Request for Proposal, select and award contract	<u>150 days</u>	day 000 to day 150
Mobilize materials and prepare for construction	<u>138 days</u>	day 151 to day 288
Perform radiation survey and construct panel closure system	149 days	day 273 to day 422
Close out	<u>30 days</u>	day 392 to day 422
File Certification of closure	<u>60 days</u>	day 422 to day 482

Note: The Schedule above indicates calendar days by which activities will be completed. Closure activities must begin within 60 days of notifying the NMED of intent to close. Required activities including awarding contract and mobilizing material may occur prior to last receipt of waste.

Some activities are conducted simultaneously and some may not require the maximum time listed. Extensions to this schedule will be requested, if needed.

^{*} If decontamination is required it will be completed prior to initiation of construction activities in a contaminated area.

TABLE I-2 ANTICIPATED OVERALL SCHEDULE FOR CLOSURE ACTIVITIES

A OTIVITY	FINAL FACILITY CLOSURE	
ACTIVITY	START	STOP
Notify NMED of Intent to Close WIPP (or to Implement Contingency Closure)	August 2024	N/A
Perform Contamination Surveys in both Surface Storage Areas	August 2024	February 2025
Sample Analysis	October 2024	May 2025
Decontamination as Necessary of both Surface Storage Areas	April 2025	November 2025
Final Contamination Surveys of both Surface Storage Areas	December 2025	July 2026
Sample Analysis	April 2026	November 2026
Prepare and Submit Container Management Unit Closure Certification	December 2026	March 2027
Dispose of Closure-Derived Waste	September 2024	November 2025
Closure of Open Underground HWDU panel	December 2025*	July 2026
Install Borehole Seals	August 2026	July 2027
Install Repository Seals	April 2027	July 2031
Recontour and Revegetate	August 2031	March 2032
Prepare and Submit Final (Contingency) Closure Certification	August 2031	March 2032
Post-closure Monitoring	May 2032	N/A

N/A--Not Applicable Refer to Figures I-3 and I-4 for precise activity titles.

^{*}This assumes the final waste is placed in this unit in November 2025 and notification of closure for this HWDU is submitted to the NMED in October 2025.

TABLE I-3 GOVERNING REGULATIONS FOR BOREHOLE ABANDONMENT

Federal or State Land	Type of Well or Borehole	Governing Regulation	Summary of Requirements
Both	Groundwater Surveillance	State and Federal regulation in effect at time of abandonment	Monitor wells no longer in use shall be plugged in such a manner as to preclude migration of surface runoff or groundwater along the length of the well. Where possible, this shall be accomplished by removing the well casing and pumping expanding cement from the bottom to the top of the well. If the casing cannot be removed, the casing shall be ripped or perforated along its entire length if possible, and grouted. Filling with bentonite pellets from the bottom to the top is an acceptable alternative to pressure grouting.
Federal	Oil and Gas Wells	43 CFR Part 3160, §§ 3162.3- 4	The operator shall promptly plug and abandon, in accordance with a plan first approved in writing or prescribed by the authorized officer.
Federal	Potash	43 CFR Part 3590, § 3593.1	(b) Surface boreholes for development or holes for prospecting shall be abandoned to the satisfaction of the authorizing officer by cementing and/or casing or by other methods approved in advance by the authorized officer. The holes shall also be abandoned in a manner to protect the surface and not endanger any present or future underground operation, any deposit of oil, gas, or other mineral substances, or any aquifer.
State	Oil and Gas Well Outside the Oil-Potash Area	State of New Mexico, Oil Conservation Division, Rule 202 (eff. 3-1-91)	B. Plugging (1) Prior to abandonment, the well shall be plugged in a manner to permanently confine all oil, gas, and water in the separate strata where they were originally found. This can be accomplished by using mud-laden fluid, cement, and plugs singly or in combination as approved by the Division on the notice of intention to plug. (2) The exact location of plugged and abandoned wells shall be marked by the operator with a steel marker not less than four inches (4") in diameter, set in cement, and extending at least four feet (4') above mean ground level. The metal of the marker shall be permanently engraved, welded, or stamped with the operator name, lease name, and well number and location, including unit letter, section, township, and range.
State	Oil and Gas Wells Inside the Oil-Potash Area	State of New Mexico, Oil Conservation Division, Order No. R-111-P (eff. 4-21-88)	F. Plugging and Abandonment of Wells (1) All existing and future wells that are drilled within the potash area, shall be plugged in accordance with the general rules established by the Division. A solid cement plug shall be provided through the salt section and any water-bearing horizon to prevent liquids or gases from entering the hole above or below the salt selection. It shall have suitable proportions—but no greater than three (3) percent of calcium chloride by weight—of cement considered to be the desired mixture when possible.

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FIGURES

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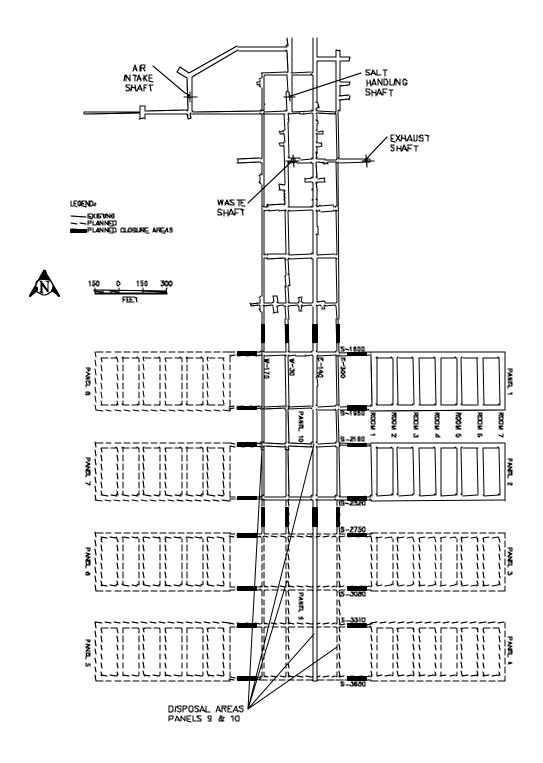
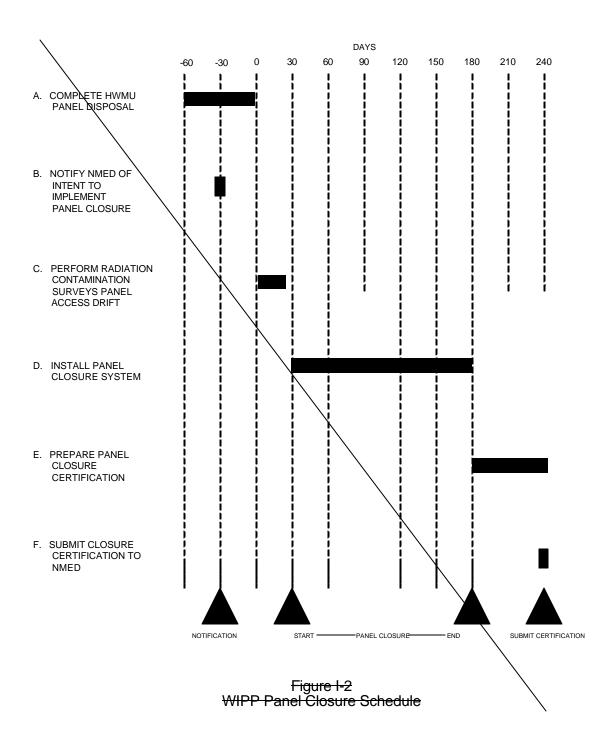


Figure I-1 Location of Underground HWDUs and Anticipated Closure Locations



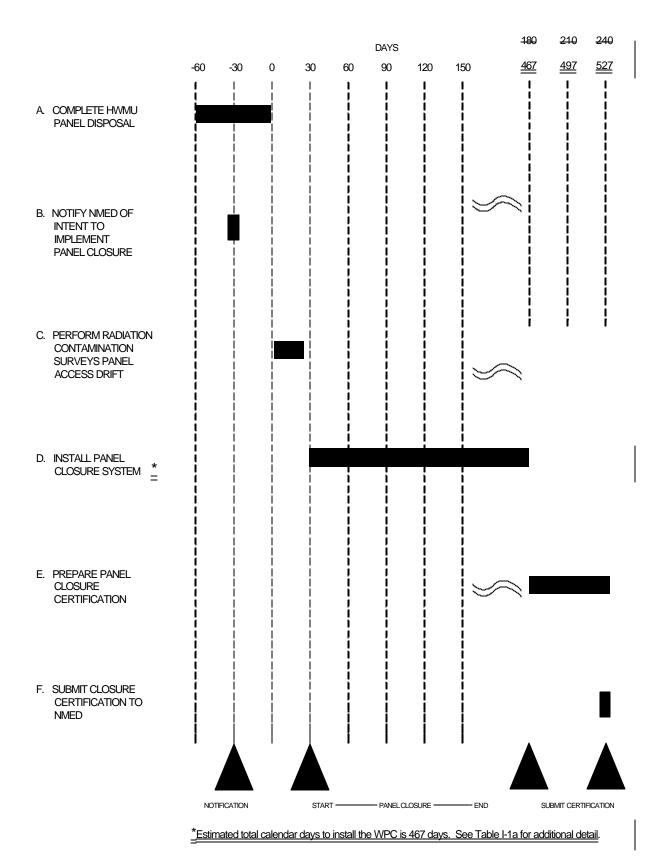


Figure I-2 WIPP Panel Closure Schedule

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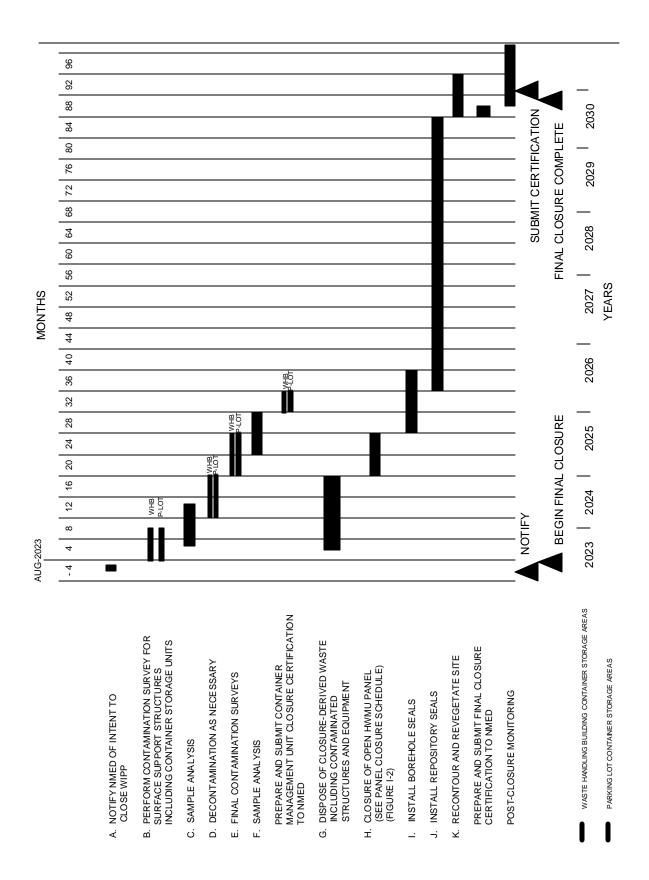


Figure I-3 WIPP Facility Final Closure Schedule

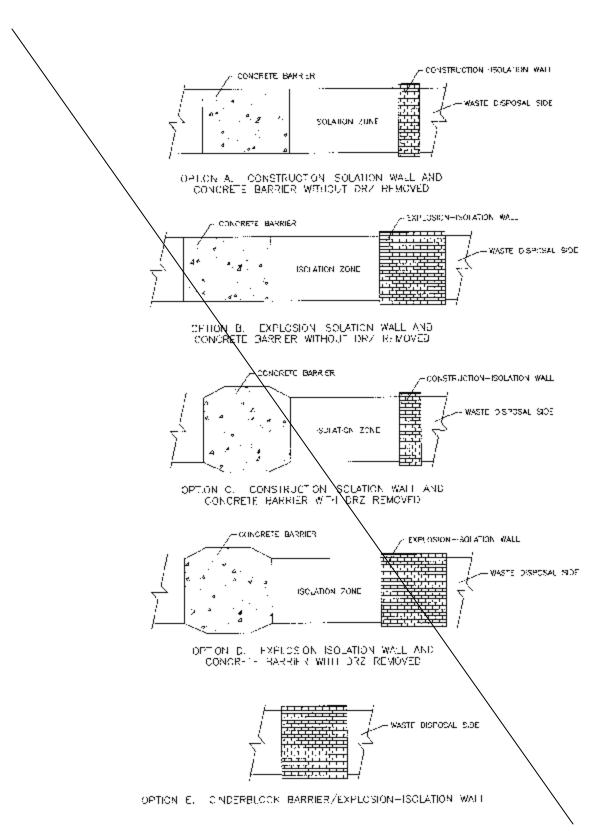
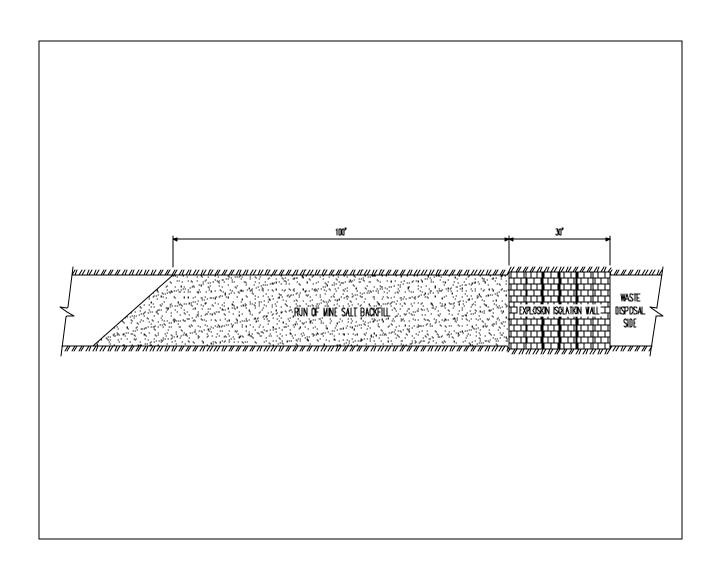


Figure I-4
Design of a Panel Closure System



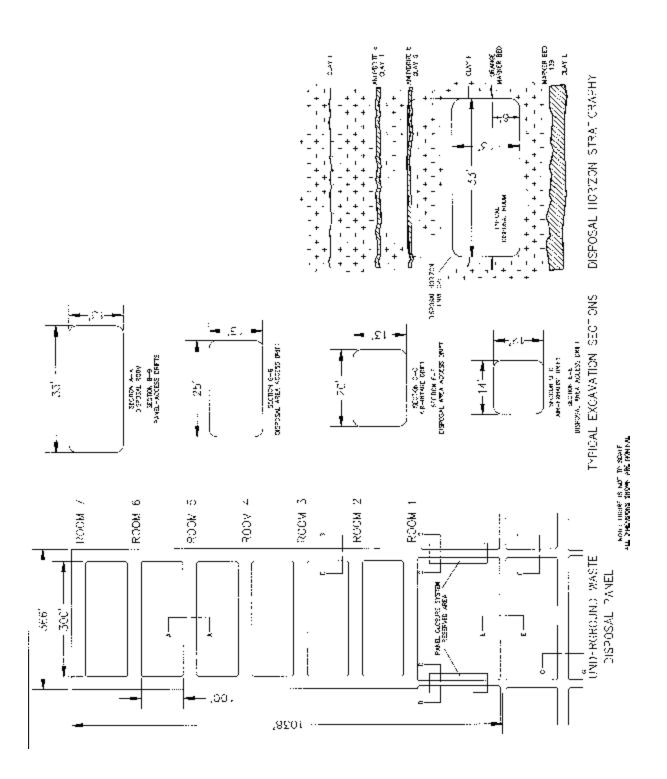


Figure I-5 Typical Disposal Panel

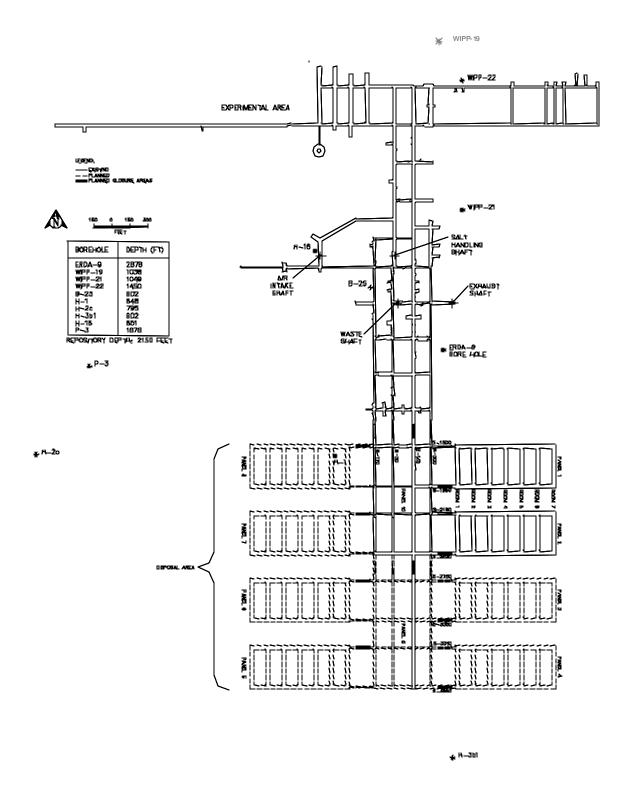


Figure I-6 Approximate Location of Boreholes in Relation to the WIPP Underground

ATTACHMENT C

PROPOSED CHANGES TO PERMIT ATTACHMENT I1, ATTACHMENT I1 APPENDIX G, AND ATTACHMENT I1 APPENDIX H

Note:

Permit Attachment I1 is proposed for replacement with the Design Report for a Revised Panel Closure System at the Waste Isolation Pilot Plant, Rev. 1, October 2002. This will result in elimination of Attachment I1 Appendix G and Appendix H.

ATTACHMENT 11

DETAILED DESIGN REPORT FOR AN OPERATIONAL PHASE PANEL CLOSURE SYSTEM

DESIGN REPORT FOR A REVISED PANEL CLOSURE SYSTEM AT THE WASTE ISOLATION PILOT PLANT

Revision 1

October 2002

Prepared for:

Westinghouse TRU Solutions, LLC

P.O. Box 2078 Carlsbad, New Mexico 88221

Prepared by:

RockSol Consulting Group, Inc.

848 Yellow Pine Avenue Boulder, Colorado 80304

DESIGN REPORT FOR A REVISED PANEL CLOSURE SYSTEM AT THE WASTE ISOLATION PILOT PLANT

Revision 1

October 2002

Any comments or questions regarding this report should be directed to the U.S. Department of Energy

Carlsbad Field Office

P.O. Box 3090

Carlsbad, New Mexico 88221

Or to Westinghouse TRU Solutions, LLC
P.O. Box 2078
Carlsbad, New Mexico 88221

This report was prepared for Westinghouse TRU Solutions, LLC by RockSol Consulting Group, Inc., under Purchase Order Number 3164.

Certification

I certify under penalty of law that this document was prepared under my supervision for Westinghouse TRU Solutions, LLC, under the RockSol Consulting Group, Inc., Quality Assurance Program. This quality assurance program is designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete.

ORIGINAL SIGNED BY:

Saeid Saeb, Ph.D., P.E.

New Mexico

Certification No. 11777

Expires December 31, 2003

Des Begernber 31, 2003

Rev. 1

10/3/2002

Executive Summary

Scope. RockSol Consulting Group, Inc., under contract to Westinghouse TRU Solutions, prepared a detailed design for a panel closure system for the Waste Isolation Pilot Plant (WIPP). Preparation of this detailed design of an operational-phase panel closure system is required to support the WIPP Hazardous Waste Facility Permit (HWFP). This report describes the detailed design for a panel closure system specific to the WIPP site. The recommended WIPP Panel Closure system (WPC) will adequately isolate the waste disposal panels from the active workings of the repository for the required design life of 35 years.

Purpose. This report provides detailed design and engineering specifications for the construction of the WPC. The WPC design will ensure a nominal operational life of 35 years. The design provides assurance that the mass release rate limits specified in the WIPP HWFP for the migration of volatile organic compounds (VOCs) will be met as specified in the relevant sections of the HWFP (e.g. Attachment N), for simplicity the point of compliance is referred to hereafter as E-300 drift. The WPC will be located in the air-intake and air-exhaust drifts (Figure ES-1-1). The system components are designed to maintain their intended functional requirements under loads generated from salt creep and a postulated methane explosion. The proposed design complies with regulatory requirements promulgated by Mine Safety and Health Administration (MSHA). The design uses common construction practices according to existing standards.

Background. The engineering design considered expected subsurface conditions at the location of the WPC. The geology is predominantly halite with inter-bedded anhydrite at the repository horizon. During the operational period, the WPC will be subject to creep from the surrounding host rock. The salt strata at the repository horizon are known to contain only trace amounts of brine.

The HWFP provides information in Module IV on Geologic Repository Disposal. The VOCs of concern in Table IV.F.2.c of the HWFP include carbon tetrachloride, chlorobenzene, chloroform, 1,1-dichloroethene, 1,2-dichloroethane, methylene chloride, 1,1,2,2-tetrachloroethane, toluene, and 1,1,1-trichloroethane.

The primary intent of the WPC is to ensure that VOC releases are less than the regulatory limits specified in the HWFP. The E-300 drift mass release rate limit equals the E-300 drift concentration limit as specified in Table IV.F.2.c of the HWFP times the minimum ventilation rate of 260,000 ft³/min (7,362 m³/min) required by the HWFP. This value establishes the current design mass release rate limits for flow of VOCs of concern from the waste disposal areas.

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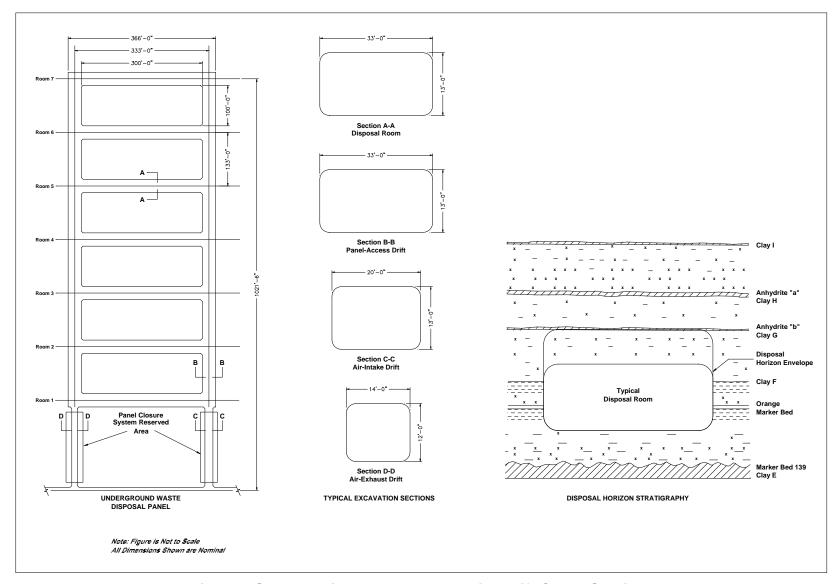


Figure ES-1-1 Typical Panel Layout with Drift Cross Sections

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While no specific requirements exist for closing disposal areas under MSHA regulations, the intent of these regulations is to safely isolate abandoned areas from active workings using barricades of "substantial construction." A previous analysis (DOE, 1996a) examined the issue of methane gas generation from transuranic waste and the potential consequences of a postulated methane explosion in closed waste disposal areas.

To demonstrate compliance with the E-300 drift mass release rate limits for the individual VOCs of concern, two air-flow models were evaluated: (1) unrestricted flow and (2) restricted flow through the panel closure system. The unrestricted air-flow model is defined as a model in which the gas pressure that develops is at, or very near, atmospheric pressure such that no back pressure exists in the disposal areas. The restricted air-flow model is defined as a model in which a back pressure develops in a closed waste disposal panel due to the restriction of flow through the panel closure system and the surrounding disturbed rock zone. The analyses were based on an assumed approximate gas generation rate of 0.1 moles per drum per year due to microbial degradation, the expected volumetric closure rate due to salt creep, the expected headspace concentration for a series of nine VOCs of concern, and the expected air ventilation rate at the E-300 drift. The analyses showed that in both air-flow models the release rate of each VOC at the E-300 drift is significantly below the permit limit. In the restricted case the release is further reduced.

Alternate Designs. Various concepts were developed for evaluation. These concepts intentionally covered a broad range. A design review committee was convened and was requested to rank the various alternatives. The design review committee carefully discussed all the alternatives, evaluated their potential performance, and recommended several of the concepts for further consideration. After further engineering evaluation and assessment, the explosion isolation wall with run of mine salt backfill was selected as the preferred alternative for the WPC. This alternative satisfies all performance specifications, is simple to construct, has a low impact on waste receipt, and is cost effective.

WIPP Panel Closure System. The WPC has two components: a 30-foot (9.1-meter) concrete block wall and a run of mine salt backfill. Figure ES-1-2 illustrates these design components. The construction methods and materials to be used to implement the design have been proven in previous mining and construction projects. No other special requirements for engineered components beyond the normal requirements for fire suppression and methane explosion or deflagration containment exist for the WPC during the operational period.

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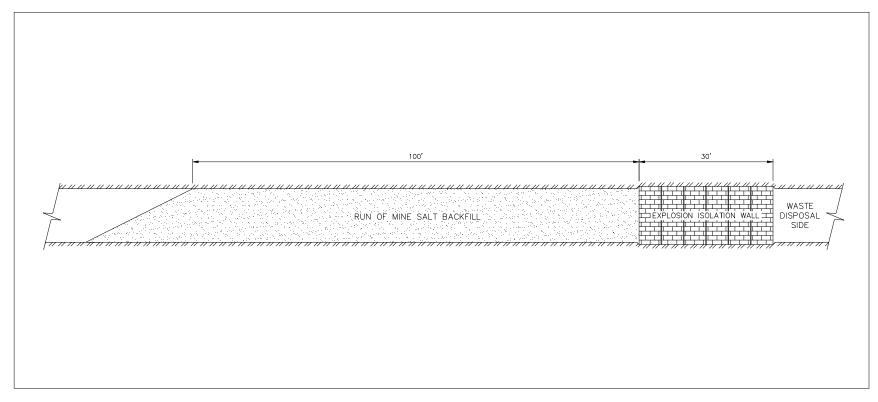


Figure ES-1-2 Explosion Isolation Wall in Combination with the Run of Mine Salt Backfill

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Design Evaluation. The evaluation of this design was performed to investigate several key design issues. This design evaluation can be divided into two components: (1) the operational requirements of the system, and (2) the structural and material requirements of the system.

The conclusions reached from the evaluation addressing the operational requirements for the WPC design are as follows:

- The mass flow rate for different VOCs through the WPC (including flow through the disturbed rock zone [DRZ], the explosion isolation wall, and the run of mine salt backfill) were demonstrated to be at least two orders of magnitude below the limits specified in Table IV.F.2.c of the WIPP HWFP.
- The Monte Carlo Simulation Method was used to assess the uncertainty of VOCs headspace concentrations, gas generation rate, and panel volume closure rate on the mass flow rate of carbon tetrachloride. The time required to reach the steady-state mass flow rate of VOCs depends on the intrinsic permeability of the flow components. In some realizations in which the mass flow rate rises rapidly to the steady-state mass flow rate, the flow is essentially unrestricted. In most cases, however, the WPC offers some resistance to flow and mass flow rates develop more slowly. In all cases, the explosion isolation wall with the run of mine salt backfill complies with the mass flow rate limit at the E-300 drift. The maximum mass flow rate through WPC calculated by this analysis was more than an order of magnitude below the mass flow rate limits specified in Table IV.F.2.c of the WIPP HWFP.
- The dimensions selected for the passive design components of the WPC are conservative, and thus ensure that these components will not require routine maintenance during the operational life of 35 years.

The conclusions reached from the design evaluation addressing the structural and material requirements of the WPC are as follows:

- Thermal cracking due to heat of hydration effects does not apply to concrete blocks.
- The salt strata at the repository horizon are known to contain only trace amounts of brine that will not degrade the main concrete block wall over the nominal operational life of 35 years.
- Detailed axisymmetric FLAC models were developed to assess the state of stress in the

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concrete block wall and surrounding rock due to creep closure of the salt. The length selected for the explosion isolation wall provides for a substantial margin of safety against structural failure.

Stress analysis showed that the wall will withstand the forces of both creep closure and the
postulated methane explosion. Further, at the likely time of a postulated explosion, the
development of confining stress on the block wall would prevent fracturing around the
block wall.

Design Components. Figure ES-1-2 illustrates the design components developed to satisfy the requirements for the WPC. The main barrier consists of a 30-foot (9.1-meter) long concrete block wall with construction joints. The concrete block wall design complies with MSHA requirements as it is made of incombustible materials of substantial construction. Surface treatment around the explosion isolation wall includes the removal of loose material to create a clean and regular surface for the construction of the block wall. The backfill consists of run of mine salt with a minimum length of 100 ft (30.5 m). Run of mine salt is a natural selection for backfill that is compatible with the environment.

The performance of the WPC design was evaluated against the performance specifications established for the panel closure system. The WPC design complies with all aspects of the performance specifications established for the panel closure system.

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List of Acronyms_

atm atmosphere

CFR Code of Federal Regulations

cm centimeter(s)

CQC Contractor Quality Control

CQCP Contractor Quality Control Plan

DOE Department of Energy
DRZ Disturbed Rock Zone

ft foot (feet)

FLAC Fast Lagrangian Analysis of Continua

g gram(s)

HASP Health and Safety Plan

HWFP Hazardous Waste Facility Permit

K Kelvin

kg kilogram(s) m meter(s)

mg milligram(s)
min minute(s)

MPa Mega Pascal(s)

MSHA Mine Safety and Health Administration

PCS Panel Closure System

ppm part(s) per million

psi pound(s) per square inch

QA/QC Quality Assurance/Quality Control

RCRA Resource Conservation and Recovery Act

s second(s)

SNL Sandia National Laboratories

TRU Transuranic

VOC(s) Volatile Organic Compound(s)
WIPP Waste Isolation Pilot Plant
WPC WIPP Panel Closure system

yr year(s)

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1.0 Introduction

The Waste Isolation Pilot Plant (WIPP), a U.S. Department of Energy (DOE) facility located near Carlsbad, New Mexico, was established for the safe disposal of defense-generated transuranic (TRU) waste. The WIPP repository is approximately 2,150 feet (ft) (655 meters [m]) below the surface, in the Salado Formation.

One important aspect of repository operations at the WIPP is the activity associated with closure of waste disposal panels. Each panel consists of air-intake and air-exhaust drifts, panel-access drifts, and seven rooms (Figure 1-1). After completion of waste disposal activities in a panel, it will be closed at the same time that waste disposal may be occurring in the other panel(s). The closure of individual panels during the operational period will be accomplished in accordance with project-specific health, safety, and environmental performance criteria.

The WIPP Panel Closure system (WPC) design is an explosion isolation wall with run of mine salt backfill. The original Panel Closure System (PCS) design was contained in DOE (1996a) and Appendix PCS of the WIPP Compliance Certification Application (CCA) (DOE, 1996b). A large portion of the design information contained in that appendix is applicable to the WPC design. This includes the application of the restricted and unrestricted flow models, heat transfer analyses, and analyses associated with the methane gas explosion. Throughout this document, the CCA appendix is referred to as Appendix PCS.

1.1 Scope

This report provides analyses of the WPC design for effectiveness of the explosion isolation wall as a gas barrier; the structural adequacy of the explosion isolation wall; and the design description of the WPC for a nominal operational period of 35 years. The WPC design provides assurance that the limit for the migration of volatile organic compounds (VOCs) will be met as specified in the relevant sections of the HWFP (e.g. Attachment N), for simplicity the point of compliance is referred to hereafter as the E-300 drift. The WPC will be located in the air-intake and air-exhaust drifts to each panel (Figure 1-1). The WPC design maintains its intended functional requirements under loads generated from salt creep and a postulated methane explosion. The design complies with regulatory requirements promulgated by Mine Safety and Health Administration (MSHA).

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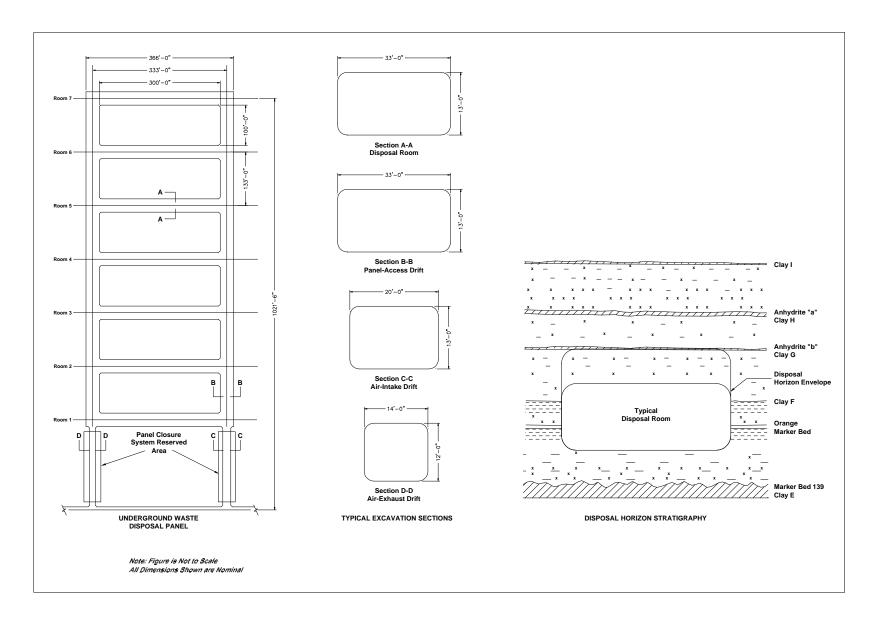


Figure 1-1 Typical Panel Layout with Drift Cross Sections

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1.2 Regulatory Requirements

1.2.1 Hazardous Waste Regulations

The Closure Plan in the WIPP HWFP was prepared in accordance with the requirements of 20.4.1.500 New Mexico Administrative Code (incorporating 40 Code of Federal Regulations §264 Subparts G, I, and X). The WPC complies with the relevant portions of those requirements.

1.2.2 Mine Safety and Health Administration

Under 30 CFR 57 "barriers and stopping" must be constructed of noncombustible materials appropriate for the specific mine category and must be of "substantial construction." Substantial construction implies construction of such strength, material, and workmanship that the barrier could withstand air blasts, methane detonation or deflagration, blasting shock, and ground movement expected in the mining environment. The WPC complies with the relevant portions of those regulations.

1.3 Report Organization

This report presents evaluations of the WPC. Chapter 2 presents the description of the design. Chapter 3 presents the design evaluations addressing the gas barrier effectiveness of the explosion isolation wall and the structural adequacy of the explosion isolation wall. Chapter 4 presents the design calculations. Chapters 5 and 6 present the technical specifications, and drawings respectively. Chapter 7 presents the conclusions to the report.

1-3 Rev. 1 10/3/2002

2.0 Design Descriptions

This chapter describes how the concept for the WPC was developed and describes the explosion isolation wall and run of mine salt backfill components of the WPC.

2.1 WPC Performance Specifications

Original design criteria were presented in Table 7-1 of DOE (1996a) and were revised in Attachment I of the HWFP as issued. These criteria were reviewed for continued applicability and only one of the performance specifications was modified, as italicized in the following list. The WPC performance specifications are:

- The panel closure system design shall limit VOC migration from a closed panel consistent with the limits found in Table IV.F.2.c of the HWFP.
- The panel closure system shall consider potential flow of VOCs through the disturbed rock zone (DRZ) in addition to flow through closure components.
- The panel closure system shall perform its intended functions under loads generated by creep closure of the tunnels.
- The panel closure system shall perform its intended function under the conditions of a postulated methane explosion.
- The nominal operational life of the closure system is thirty-five (35) years.
- The panel closure system for each individual panel shall not require routine maintenance during its operational life.
- The panel closure system shall address the most severe ground conditions expected in the waste disposal area.
- The design class of the panel closure system shall be IIIb (which means that it is to be built to generally accepted national design and construction standards).
- The design and construction shall follow conventional mining practices.
- Structural analysis shall use data acquired from the WIPP underground.
- Materials shall be compatible with their emplacement environment and function.

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- Treatment of surfaces in the closure areas shall be considered in the design.
- Thermal cracking of concrete shall be addressed.
- During construction, a Quality Assurance/Quality Control (QA/QC) program shall be established to verify material properties and construction practices.
- Construction of the panel closure system shall consider shaft and underground access and services for materials handling.

Various concepts were developed for evaluation. These concepts intentionally covered a broad range. For each of these concepts, the estimated conductance was calculated and a preliminary construction cost was estimated. These were intended only as aids to facilitate ranking during the selection process.

A design review committee was convened and was requested to rank the various alternatives. The design review committee carefully discussed all the alternatives, evaluated their potential performance, and recommended several of the concepts for further consideration. After further engineering evaluation and assessment, the explosion isolation wall with run of mine salt backfill was selected as the preferred alternative for the WPC. This alternative satisfies all performance specifications, is simple to construct, has a low impact on waste receipt, and is cost effective.

2.2 Design Concept

The selected design for WPC is a combination of a mortared concrete block wall and a run of mine salt backfill. Figure 2-1 illustrates these design components. The construction methods and materials used to implement the design are well proven in previous mining and construction projects. This configuration satisfies the E-300 drift mass flow rate limits for the flow of VOCs of concern out of the panel. The selected design will resist the temperature transients and methane explosion pressure as discussed in Sections 3.2.2 through 3.2.4.

2.3 Design Components

The following subsections present system and components design features.

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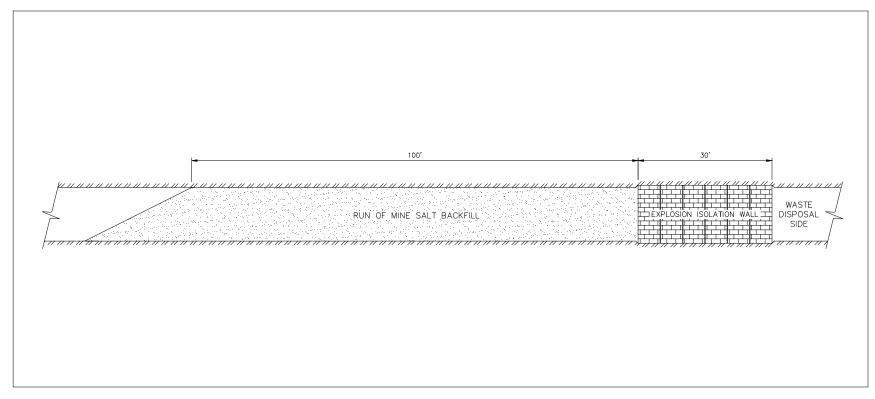


Figure 2-1 Explosion Isolation Wall in Combination with the Run of Mine Salt Backfill

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2.3.1 Explosion Isolation Wall

The explosion isolation wall consists of a 30-foot (9.1-meter) long, mortared, solid block wall as shown in Figure 2-2. Detailed structural analyses have been performed (Section 3.2.4) to assess the development of stresses within the block wall. These analyses showed that a 30-foot (9.1-meter) long concrete block wall reduces the relative proportion of the compressive abutment zones near the ends of the wall to an acceptable level. Five construction joints were introduced to mitigate the axial tensile stresses, which develop in the wall due to salt creep. The construction joints also eliminate the effects of potential differential displacements along the axis of the wall. Since the construction joints are normal to the direction of VOCs flow out of the closed panel they have minimal impact on flow conductance of the wall.

The blocks of the wall are 8x8x16 inches and have a minimum unconfined compressive strength equal to 5000 psi (34.5 MPa). The specifications include materials testing to verify material properties and construction practices.

The concrete block wall design complies with MSHA requirements. It is made of incombustible materials and is of substantial construction. The block wall can also resist forces of a postulated methane explosion under creep load from the surrounding rocksalt as discussed in Section 3.2.4. The surrounding salt surfaces will be prepared to create a smooth, clean surface for the placement of bricks and mortar.

The explosion isolation wall with the run of mine salt backfill separates the active ventilated underground workings from the closed panels. The restricted flow analysis presented subsequently (Section 3.1.1) shows an adequate design margin for meeting VOC release limits.

2.3.2 Backfill

The backfill consists of run of mine salt with a minimum length of 100 ft (30.5 m). Run of mine salt is a natural material for backfill that is completely compatible with the environment. In the absence of the block wall, run of mine salt backfill provides protection against a methane explosion. An analysis was conducted to assess the effect of methane gas explosion on the backfill. In this analysis, the explosion isolation wall was ignored and the run of mine salt backfill alone resisted the impact loading from the postulated methane explosion. The analysis showed that the backfill will absorb the explosion impact due to deflagration.

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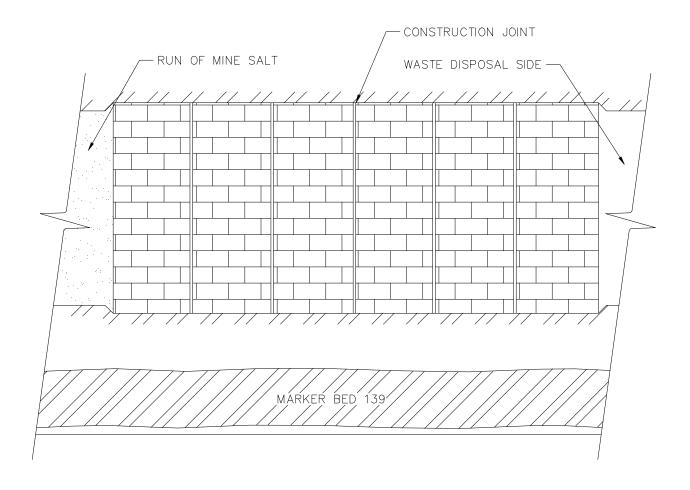


Figure 2-2 Explosion Isolation Wall

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3.0 Design Evaluations

This chapter presents the evaluations that support the design of the WPC: (1) analyses addressing the operational requirements, and (2) analyses addressing the material and structural requirements. The first group includes air-flow analyses, an advection analysis, and an uncertainty analysis of air-flow. The second group includes material compatibility evaluation, heat generation, explosion evaluation, stress analysis and fracture-propagation evaluation.

3.1 Analyses Addressing Operational Requirements

To evaluate the effectiveness of the WPC, air-flow analyses were performed to examine the flow of VOCs through the WPC. The following sections address the air-flow analyses, the advection analysis, and air-flow uncertainty analysis. These analyses support the WPC design for both the overall protection of human health and the environment, and compliance at the E-300 drift as required by HWFP.

3.1.1 Air-Flow Analyses

The purpose of the air-flow analyses is to evaluate the flow of VOCs through the WPC. The effective intrinsic permeability of the WPC is evaluated and used as input to the air-flow model (DOE, 1996a) to assess VOC(s) flow performance.

In this study, two air-flow models are considered: (1) unrestricted flow, and (2) restricted flow through the panel closure system. The unrestricted air-flow model is defined as a model in which the gas pressure that develops is at, or very near, atmospheric pressure such that no back pressure exists in the disposal areas. The restricted air-flow model is defined as a model in which a back pressure develops in a closed waste disposal panel due to the restriction of flow through the panel closure system and the surrounding disturbed rock zone. The analyses are based on an assumed gas generation rate of 8,650 moles per panel per year (0.1 moles per drum per year [DOE, 1996a] for 86,500 drums per panel [HWFP]) due to microbial degradation, an average volumetric closure rate of 31,430 ft³ (890 m³) per year due to salt creep (Appendix B), the expected headspace concentration for nine VOCs (Appendix A), and the minimum mine ventilation rate of 260,000 ft³/min (7,362 m³/min) required by HWFP at E-300 drift.

3.1.1.1 Evaluation Procedure

In the restricted flow model, the gases in the waste-emplacement area are in part compressed in the void space within a panel and in part flow into the main return air. The restricted flow model

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is based on the following assumptions:

- Gases (including VOCs) within the void space will obey the Ideal Gas Law. The gases will
 be generated at a rate of 0.1 moles per drum per year (DOE, 1996a) and will be stored by an
 increase in gas pressure. The rate of pressure buildup will be so gradual that it occurs at
 constant temperature.
- Volumetric reduction due to creep will reduce the void space at a rate of 31,430 ft³ (890 m³) per year (Appendix B) and will result in pressurization.
- Flow of gas out of the panel will obey Darcy's Law under quasi steady-state conditions.
 Under quasi steady-state conditions, the air pressure within the WPC will change so gradually that the compressive storage of the air within the void space of the WPC could be neglected.
- Rates of gas generation, air outflow, and change in compressive storage will balance.
- Hydrodynamic dispersion through the barrier will be neglected.
- Analysis will consider the superposition of flow rates from individual panels according to the operating schedule for a nominal operational life of 35 years.

The air-flow under these assumptions follows a nonlinear system of two first-order ordinary differential equations. The model is characterized by molar gas generation and reduction in void volume that together result in an increase in air pressure.

The problem can be solved using the system of nonlinear ordinary differential equations as derived in Appendix A:

$$\frac{dp}{dt} = R \cdot T \cdot \frac{\left(g_r - \frac{p}{RT} \cdot C \cdot \frac{p - p_{atm}}{g}\right) \cdot V - n\frac{dV}{dt}}{V^2}$$
 (Equation 3-1)

$$\frac{dn}{dt} = g_r - \frac{p}{R \cdot T} \cdot C \cdot \frac{p - p_{atm}}{g}$$
 (Equation 3-2)

where

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dt = Change in time (years)

R = Universal gas constant (atm . m³/(mole . K))

T = Absolute temperature (K)

n = Moles of gas in the panel

p = Pressure (atm)

 $p_{atm} = \text{Atmospheric pressure (atm)}$

C = Conductance (m²/s) of the panel closure system = $K_s \cdot \frac{A}{L}$

 K_s = Effective air conductivity of the panel closure system (m/s)

A = Cross sectional area of the panel closure system (m^2)

L = Flow path length of the panel closure system (m)

g = Air density (kg/(m² . s²))

 g_r = Gas generation rate (moles/yr)

V = Volume of the panel void space (m³)

 $\frac{dV}{dt}$ = Panel volumetric closure rate (m³/yr)

 $\frac{dp}{dt}$ = Panel pressure rate (atm/yr)

 $\frac{dn}{dt}$ = Panel molar storage rate (mole/yr).

The above relationships are subject to the following initial conditions: (1) the pressure in the panel will be atmospheric; and (2) the moles of gas in the panel equal the moles of gas occupying the initial panel void volume at the temperature of the repository at the time of panel closure.

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The effective air conductivity of the panel closure system (K_s) can be expressed in terms of the effective intrinsic permeability of the panel closure system (k_s) and the fluid properties of air as (Freeze and Cherry, 1979):

$$K_s = \frac{k_s \cdot \mathbf{r} \cdot g}{\mathbf{m}}$$
 (Equation 3-3)

where

r = Air mass density (kg/m³)

g = Acceleration due to gravity (m/s²)

 \mathbf{m} = Absolute air viscosity (kg/(m . s))

The effective intrinsic permeability of the WPC (k_s) can be evaluated by considering the intrinsic permeabilities of the various flow components over their respective areas, as presented in Table 3-1.

Permeability measurements in salt were summarized in the original design report (DOE, 1996a). These data show a zone of increased permeability (10^{-18} to 10^{-20} ft² [10^{-19} m² to 10^{-21} m²]) 3 to 42 ft (1 to 14 m) from the excavation surface. Based on these observations, the calculations assumed that the cross-sectional area for flow through the DRZ and the WPC will equal nine times the air-intake and air-exhaust drift area or that the DRZ extends out three radii from the center (DOE, 1996a).

As shown in Table 3-1, a distinction is made between "dilated salt", and "fractured salt". Dilated salt exhibits a higher permeability than intact salt due to relief of the lithostatic stresses, and this corresponds to the increased permeability zone observed by Case and Kelsall (1986). The more conservative value of 10^{-19} m² is used here for the intrinsic permeability of dilated salt. The fractured salt refers to the highly fractured zone in the immediate vicinity of the openings.

The intrinsic permeability of the concrete block wall was estimated from the intrinsic permeabilities of the concrete blocks and the interface zone between the mortar and concrete blocks that is tributary to each block. A parallel system was used to calculate the intrinsic permeability of the concrete block wall from the intrinsic permeabilities of its flow components (concrete blocks and interface). It is assumed that the intrinsic permeability of mortar is the same as that of concrete block. For the concrete blocks an intrinsic permeability of $k_c = 1.0 \times 10^{-19} \,\mathrm{m}^2$

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(PCA, 2002) was used with a flow area of $A_c = 8 \times 16 \text{ in}^2 = 128 \text{ in}^2 = 0.083 \text{ m}^2$. Further, the intrinsic permeability of the interface zone surrounding the concrete blocks was estimated using an interface zone aperture of 11 micron (Fernandez et al., 1994). For a smoothwall aperture of b, the interface zone intrinsic permeability is equal to $b^2/12$ (Fernandez et al., 1994). For an aperture of $b = 11 \times 10^{-6}$ m, the interface zone intrinsic permeability of $k_i = 1 \times 10^{-11}$ m² is obtained. The area of the interface zone surrounding each concrete block is $A_i = 2(16 \text{ in} + 8 \text{ in}) b = 1.34 \times 10^{-5} \text{ m}^2$. The intrinsic permeability of the concrete block wall can be calculated using Equation A-14 of Appendix A as follows:

$$k_{wall} = \frac{k_c \cdot A_c + k_i \cdot A_i}{A_c + A_i}$$
 (Equation 3-4)

This results in an intrinsic permeability of 1.64×10^{-15} m² for the concrete block wall which is rounded to 2×10^{-15} m².

The run of mine salt backfill is placed in a loose state in the air-intake and air-exhaust drifts of each panel. Case et al. (1987) reports on an experiment on WIPP crushed salt that measured the relationship of hydraulic conductivities to porosity when subjected to confining pressure. The test results showed that the intrinsic permeability might equal 0.01 darcy (10^{-14} m²) at 15 percent porosity. For high porosities from 35 to 40 percent, the test results showed that the intrinsic permeability might equal 10^2 darcy (10^{-10} m²). In the current analysis, an intrinsic permeability of 10 darcy (10^{-11} m²) was used. This is a reasonable value for the expected range of porosities.

Table 3-1 Intrinsic Permeability of Flow Components

	Intrinsic Pe		
Component	ft ²	m ²	References
Dilated salt	1x10 ⁻¹⁸	1x10 ⁻¹⁹	DOE, 1996a
Fractured salt	1x10 ⁻¹⁴	1x10 ⁻¹⁵	DOE, 1996a
Clay seams	1x10 ⁻¹⁶	1x10 ⁻¹⁷	DOE, 1996a
Marker Bed 139	1x10 ⁻¹⁵	1x10 ⁻¹⁶	DOE, 1996a
Interface zone	1x10 ⁻¹⁰	1x10 ⁻¹¹	DOE, 1996a
Concrete block wall	2x10 ⁻¹⁴	2x10 ⁻¹⁵	Calculated
Run of mine salt	1x10 ⁻¹⁰	1x10 ⁻¹¹	Case et al., 1987

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Finally, for the clay seams, Marker Bed 139, and the interface zone between the concrete block wall and the surrounding rocksalt, the values from the previous design (DOE, 1996a) were used.

To calculate the void space volume of the panel (V), the analysis assumed that the volume of the waste is equal to the total waste capacity of a panel ($600,000 \text{ ft}^3$ [$16,990 \text{ m}^3$]) (DOE, 1994) times the assumed average solid volume of the waste drums (23 percent) (IT, 1994). The analysis uses a solid waste volume equal to $138,000 \text{ ft}^3$ ($3,908 \text{ m}^3$) for the panel and this volume remains constant during the operational life of the panel.

The waste-emplacement capacity of a panel includes the seven rooms and the panel access drifts from Room 1 to Room 7. Field data from geotechnical engineering measurements were used to determine creep closure rates for 35 years as presented in Appendix B.

A model for unrestricted flow of VOCs was also developed to predict the mass flow rates of VOCs (Appendix A). The results of unrestricted flow analysis are used for comparison with the restricted flow case.

3.1.1.2 Modeling Results

The HWFP provides information in Module IV on Geologic Repository Disposal. Table IV.F.2.c of this module presents the E-300 drift concentration limits for VOCs of concern. These limits are shown on appropriate figures. The VOCs of concern in Table IV.F.2.c of the HWFP include carbon tetrachloride, chlorobenzene, chloroform, 1,1-dichloroethene, 1,2-dichloroethane, methylene chloride, 1,1,2,2-tetrachloroethane, toluene, and 1,1,1-trichloroethane.

The E-300 drift mass release rate limit equals the E-300 drift concentration limit as specified in Table IV.F.2.c of the HWFP times the minimum mine ventilation rate of 260,000 ft³/min (7,362 m³/min) required by HWFP. This value establishes the current design mass release rate limits for flow of VOCs of concern from the waste disposal areas.

Comparisons are made of the expected mass release rate of VOCs of concern to the E-300 drift mass release rate limits. The calculation of the expected mass flow uses the product of (1) an estimate of the actual headspace concentrations for each of the VOCs of concern, and (2) an estimate of the actual gas flow rate from the restricted flow model as presented previously.

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The sources of information for the actual VOCs headspace concentrations (Appendix A) include Table A-2 of DOE (1996a), and the WIPP Waste Information System Headspace Gas Concentration Report (2002). The maximum values for actual mass concentrations from the two sources of information are used in the present analysis.

Figure 3-1 shows the expected pressure buildup in a single panel after closure. The pressure within the panel builds up gradually due to the large compressibility of the panel void space relative to the air-flow rate out of the panel. The restricted air-flow rate also builds up gradually to a steady-state flow rate.

Figure 3-2 presents the expected mass release rates for the VOCs of concern versus time for comparison to the E-300 drift mass release limits for the repository. In these analyses, the current panel closure schedule (Westinghouse, 2002) is considered, and the expected mass release rates from individual panels as they are closed are superimposed in time. The analyses show that in every case, the expected mass release rate from the repository is much lower than E-300 drift mass release rate limit for the VOCs of concern.

3.1.1.3 Conclusions

The air-flow model (DOE, 1996a) was used to predict the expected mass flow rate for VOCs of concern through a panel closure system consisting of a concrete block wall with run of mine salt backfill. The analysis suggests that VOC flow over the operational period will be at least two orders of magnitude below the HWFP limits established at the E-300 drift (Figure 3-2).

3.1.2 Advection Evaluation

The purpose of the advection evaluation is to assess contaminant transport time through various media. As panel pressure develops with time, gases will travel through the panel closure system. The restricted air-flow model considered that the VOC concentration front will instantaneously develop in the active underground workings and the gases would then flow by advection. The more detailed analysis presented below considers the flow distribution in different components.

3.1.2.1 Evaluation Procedure

The relative significance of each of the air-flow zones can be evaluated by studying flow conductance. The flow conductance through a parallel system is calculated as follows (Freeze and Cherry, 1979):

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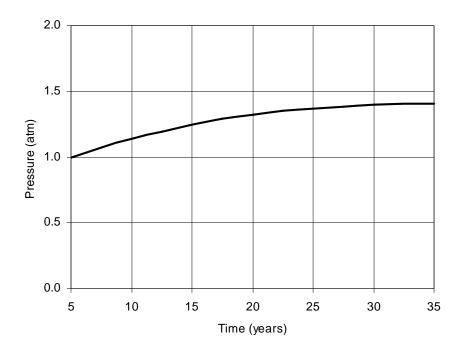
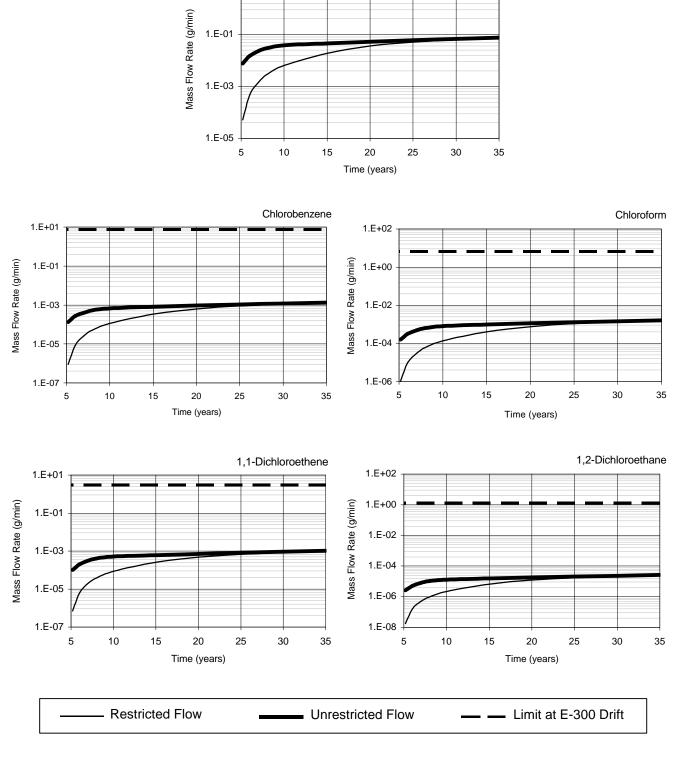


Figure 3-1 Pressure Buildup with Time for a Single Panel

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Carbon Tetrachloride

Figure 3-2 Migration Rates versus E-300 Drift Limit Values for the VOCs of Concern

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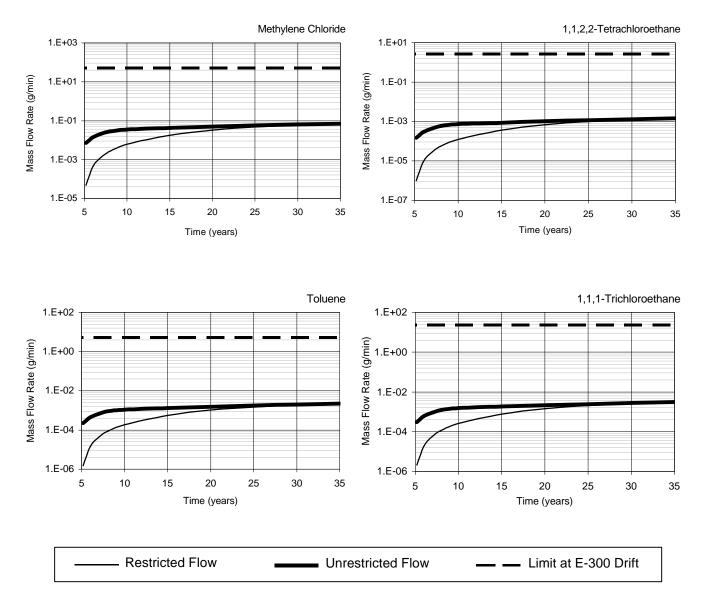


Figure 3-2 (continued) Migration Rates versus E-300 Drift Limit Values for the VOCs of Concern

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$$C = \sum \frac{K_i \cdot A_i}{L_i}$$
 (Equation 3-5)

where

C = Flow conductance of the system (m²/s)

 K_i = Air conductivity of the i^{th} component (m/s)

 A_i = Cross sectional area of the i^{th} component (m²)

 L_i = Length of the i^{th} component (m)

The conductance through the WPC will depend on the air conductivity and cross-sectional area of the flow components. Table 3-2 summarizes these values for each component. Since the conductance of run of mine salt is at least four orders of magnitude higher than that of any other component, the breakthrough of VOCs through run of mine salt occurs very rapidly. Therefore, in the advection analysis the effect of run of mine salt is neglected. The calculations show that flow through the block wall and fractured salt will dominate the conductance.

In Table 3-2, the flow area of the interface zone between the 14 ft x 21 ft concrete block wall and surrounding rocksalt is based on an interface zone aperture of $b = 11 \times 10^{-6}$ m (Fernandez et al., 1994). This results in an interface flow area of $A_i = 2(14 \text{ ft} + 21 \text{ ft})$ $b = 2.34 \times 10^{-4} \text{ m}^2$. For a smoothwall aperture of b, the interface zone intrinsic permeability is equal to $b^2/12$ (Fernandez et al., 1994). For an aperture of $b = 11 \times 10^{-6}$ m, the interface zone intrinsic permeability of $k_i = 1 \times 10^{-11}$ m² is obtained. The interface zone air conductivity can be calculated from Equation 3-3. Using the air density of $\mathbf{g} = \mathbf{r} \cdot \mathbf{g} = 0.0735 \text{ lbf/ft}^3$ (11.55 kg/(m² · s²)) and air viscosity of $\mathbf{m} = 3.85 \times 10^{-7}$ lbf s/ft² (1.84x10⁻⁵ kg/(m · s)) (Lindeburg, 1986), the interface zone air conductivity is obtained equal to 6.26×10^{-6} m/s.

The breakthrough of VOCs through the WPC under the assumption of advection will occur when the VOC front has traversed its length. The average linear velocity equals the Darcy flux divided by the effective porosity for the various flow components. The average linear velocity, neglecting compressibility effects of the gas, is given by (Freeze and Cherry, 1979):

$$V(p(t))_{avg_i} = \frac{K_i \cdot (p(t) - p_{atm})}{n_e \cdot L \cdot \mathbf{g}}$$
 (Equation 3-6)

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where

 $V(p(t))_{avg_i}$ = Average linear velocity for the i^{th} component (m/s)

 K_i = Air conductivity of the i^{th} component (m/s)

p(t) = Panel internal pressure as a function of time (atm)

 p_{atm} = Atmospheric pressure (atm)

L = Length of the barrier (m)

g = Air density (kg/(m² . s²))

 n_e = Effective porosity

The following assumptions were made in this advection model:

- The air-flow velocity will be constant along the panel closure system.
- The gases (including VOCs) within the void space will obey the Ideal Gas Law.

Table 3-2 Air Conductance Through System Components

Component	Effective Porosity	Air Conductivity (m/s)	Approximate Cross-Sectional Area (m²)	Conductance per Unit Length (m³/s)
Dilated salt ¹	0.001	6.26x10 ⁻¹⁴	170	1.0x10 ⁻¹¹
Fractured salt ¹	0.040	6.26x10 ⁻¹⁰	16	1.0x10 ⁻⁸
Clay seams ¹	0.400	6.26x10 ⁻¹²	0.09	5.6x10 ⁻¹³
Marker Bed 139 ¹	0.040	6.26x10 ⁻¹¹	11	6.9x10 ⁻¹⁰
Interface ²	1.000	6.26x10 ⁻⁶	2.34x10 ⁻⁴	1.5x10 ⁻⁹
Concrete block wall ²	0.200	1.25x10 ⁻⁹	27	3.4x10 ⁻⁸
Run of mine salt ³	0.440	6.26x10 ⁻⁶	27	1.7x10 ⁻⁴

¹DOE, 1996a

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² Calculated

³Case et al., 1987

- The flow of air out of the panel will obey Darcy's law under quasi steady-state conditions.
 Under quasi steady-state conditions, the air pressure within the panel closure system will change so gradually that the compressive storage of air within the void space of the panel closure system will be neglected.
- The two-phase flow and interactions between air and brine will be neglected, although the re-saturation of salt would tend to reduce the flow of VOCs through the panel closure system.

The air-flow average linear velocity as a function of time was calculated for each component of the WPC using the maximum pressure determined from the air-flow model (DOE, 1996a). The breakthrough time for advective transport was then determined for each of the WPC components (fractured salt, MB 139, clay seams, and the explosion isolation wall).

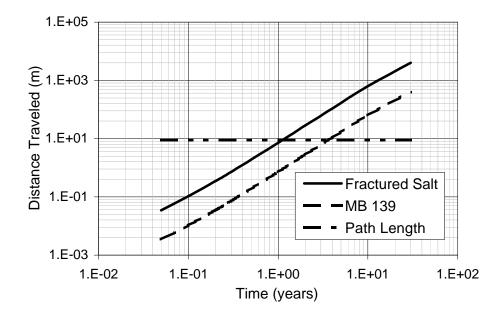
3.1.2.2 Modeling Results

In the model presented for air-flow, the pressure varies as a function of time for flow through the WPC. This will result in a change in the average linear velocity as a function of time that was calculated for each of the various components (fractured salt, MB 139, clay seams, and the explosion isolation wall).

Breakthrough times for a WPC due to advection were computed and are shown in Figure 3-3. The advection analysis suggests that for fractured salt and the mortared block wall, average linear velocities will be high due to high permeability, and low porosity, and that VOC breakthrough may occur within one to several years.

Previous analysis (DOE, 1996a) evaluated the effects of hydrodynamic dispersion on VOC transport through the WPC, using a one-dimensional dispersion model (Freeze and Cherry, 1979). This analysis showed that since breakthrough due to advection occurs rapidly through the dominant flow paths within several years, the effects of hydrodynamic dispersion are negligible. The analysis presented in this report also shows a similar rapid breakthrough through fractured salt in one to several years, as was the case in the previous analysis.

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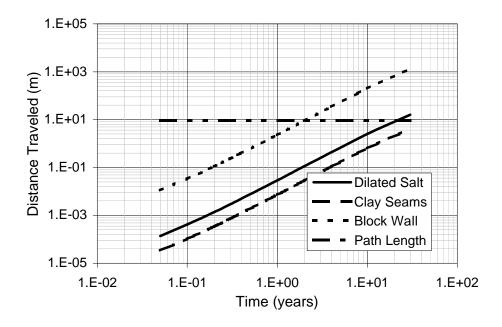


Figure 3-3 Breakthrough Time for VOCs through Several Media

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3.1.2.3 Conclusion

The restricted air-flow analysis of Section 3.1.1 showed that the mass flow rates of VOCs of concern will remain well below the HWFP required E-300 drift limit. The results of advection analysis suggest the appropriateness of the restricted flow model (DOE, 1996a) for the instantaneous breakthrough of VOCs. The advection analysis showed that for fractured salt and the mortared block wall, average linear velocities will be high due to high permeability, and low porosity, and that VOC breakthrough may occur within one to several years. While it may appear that this breakthrough time is short, the quantities involved are so small that, as was concluded in Section 3.1.1.3, VOC flow over the operational period will be at least two orders of magnitude below the HWFP required limit in the E-300 drift.

3.1.3 Monte Carlo Simulation of VOC Release

This section presents a Monte Carlo Simulation Analysis (Hahn and Shapiro 1967) for mass flow rate of carbon tetrachloride over 35 years of operation. Carbon tetrachloride is used as a surrogate for all VOCs of concern since it is likely to be present in the greatest concentration in a closed panel. In the Monte Carlo Simulation Method, uncertain input parameters are represented by separate probability distribution functions. Each of the uncertain input parameters is sampled to develop multiple realizations. It is assumed that the uncertain input parameters are independent of each other and that the covariance between the input parameters can be neglected. A deterministic function or model is then used to evaluate the output parameter (in this case, the mass flow rate of carbon tetrachloride) for each set of realization of input parameters.

In an analysis of the flow of VOCs from a panel, a number of uncertain input parameters can be identified. For example, the concentration of VOCs can vary within and between panels, so the actual headspace concentration can be considered as uncertain input for calculation purposes. The migration of VOCs depends on the panel volumetric closure rate and the molar gas generation rate, both of which are uncertain parameters. Finally, in the case of restricted flow, the intrinsic permeabilities of the WPC (for both closure components and the surrounding disturbed rock zone) also are a source of uncertainty.

In the current Monte Carlo Simulation, only the restricted flow of VOCs is considered. A schematic representation of the Monte Carlo Simulation for restricted flow analysis is shown in Figure 3-4. Each of the uncertain inputs is discussed in the following sections:

Headspace concentration: The VOC inventory perhaps represents the most significant source of uncertainty. WIPP receives waste from multiple facilities with multiple waste streams. Both the

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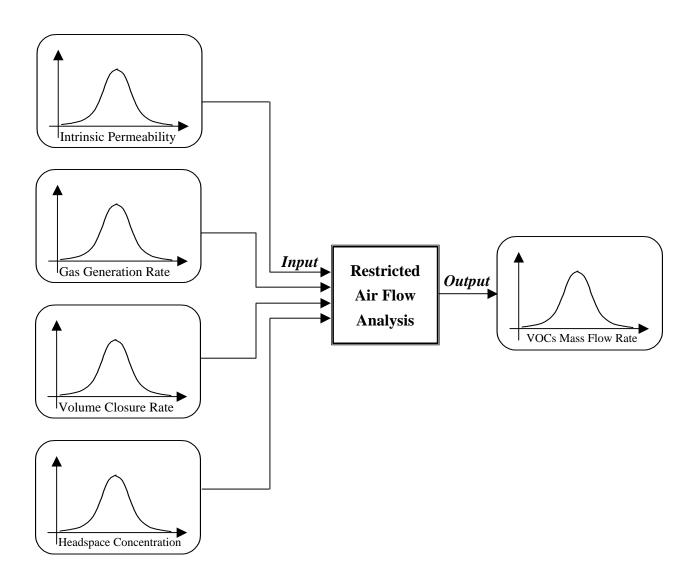


Figure 3-4 Monte Carlo Simulation of Restricted Air-Flow Analysis

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unrestricted and restricted flow models assume that the headspace concentrations serve as a constant source of VOCs. This assumption is conservative because most containers only have trace quantities of VOCs, either trapped in the headspace or on the surfaces of the various waste components. It is likely that only a small number of waste containers have a significantly greater source of VOCs such as a solvent-soaked rag. Only this small number of waste containers have a realistic likelihood of maintaining a constant headspace VOC concentration as gas generation proceeds.

The current project baseline uses a headspace concentration of 3625.77 mg/m³ for carbon tetrachloride (DOE, 1996a). To account for the uncertainty, it is assumed that the headspace concentration for carbon tetrachloride ranges from 0 to 7250 mg/m³ with a uniform distribution.

Gas generation rate: The next uncertain parameter is the gas generation rate. The current project baseline uses a gas generation rate of 0.1 moles per drum per year. In the current uncertainty analysis it is assumed that the gas generation rate ranges from 0 to 0.2 moles per drum per year with a uniform distribution. The uniform distribution provides an estimate of variance that is higher than that for a normal distribution. It is therefore conservative to assume that the molar gas generation rate is uniformly distributed.

Volumetric closure rate: Another uncertain parameter is the volumetric closure rate. In the original design the panel closure rate was based upon data from Panel 1. Since that time, Panel 2 has been excavated, and data are available for assigning the uncertainty. The air-flow analysis presented in Section 3.1.1 used an average volumetric closure rate of 890 m³ (31,430 ft³) per year (Appendix B). For the purpose of uncertainty analysis, it is assumed that the volumetric closure rate is uniformly distributed between 600 (21,200) to 1200 m³ (42,400 ft³) per year.

Intrinsic permeabilities: The remaining uncertain parameters are the intrinsic permeabilities of the various flow components. Log uniform distributions are used in this analysis for intrinsic permeabilities of various flow components. The ranges of intrinsic permeabilities selected for the Monte Carlo Simulation Analysis are presented in Table 3-3.

The intrinsic permeability of salt in the disturbed rock zone includes the intrinsic permeability of dilated salt and fractured salt. Within the first meter of most excavations, some fractures parallel to the drift are observed from boreholes at the midheight of the rib (DOE, 1995). In this region, the permeabilities are generally greater than at any other location in the salt. Between 3 and 6 ft (1 and 2 m) into the rib, permeabilities decrease to about 10^{-19} m² and below; beyond 6 ft (2 m), the permeabilities rapidly decrease to the value associated with intact salt (10^{-22} m²). Based on

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these observations, the analysis assumes that the dilated salt has a range of intrinsic permeabilities from 10^{-20} to 10^{-17} m². Also, the analysis assumes the fractured salt intrinsic permeability ranges from 10^{-17} to 10^{-12} m². Thus the combined range of the dilated salt and fractured salt values is exceptionally broad and covers the extreme range of values commonly used in various other WIPP-related assessments.

Freeze and Cherry (1979, p. 29) present a range of intrinsic permeabilities for clay, which can be used to estimate values for the clay seams. The range selected here is from 10^{-19} to 10^{-16} m².

Single-phase brine and nitrogen permeabilities were measured in the laboratory for specimens of MB 139 taken from the underground workings at the WIPP (DOE, 1995). Permeabilities to gas ranged from approximately 1.8×10^{-19} to 2.5×10^{-17} m², and the Klinkenberg-corrected equivalent liquid permeabilities ranged from 1.4×10^{-18} to 1.6×10^{-17} m². Measured permeabilities to brine ranged from 4.4×10^{-20} to 9.7×10^{-17} m². Based upon these values, the range of intrinsic permeability for the MB 139 is selected as from 1×10^{-20} to 1×10^{-16} m².

The intrinsic permeability for the interface zone between the concrete block wall and the surrounding rocksalt is estimated based on a smoothwall aperture range from b = 2 to b = 16 microns (Fernandez et al., 1994). For a smoothwall aperture of b, the interface zone intrinsic permeability is equal to $b^2/12$ (Fernandez et al., 1994). The results range from 3.33×10^{-13} to 2.13×10^{-11} m² for the interface zone intrinsic permeability.

Table 3-3 Ranges of Intrinsic Permeabilities in the Monte Carlo Simulation Analysis

Median	Lower Value (m ²)	Upper Value (m²)
Dilated Salt	1.00x10 ⁻²⁰	1.00x10 ⁻¹⁷
Fracture Salt	1.00x10 ⁻¹⁷	1.00x10 ⁻¹²
Clay Seams	1.00x10 ⁻¹⁹	1.00x10 ⁻¹⁶
Marker Bed 139	1.00x10 ⁻²⁰	1.00x10 ⁻¹⁶
Interface Zone	3.33x10 ⁻¹³	2.13x10 ⁻¹¹
Explosion Isolation Wall	1.00x10 ⁻¹⁷	1.00x10 ⁻¹³
Run of Mine Salt Backfill	1.00x10 ⁻¹⁴	1.00x10 ⁻¹⁰

The intrinsic permeability of the concrete block wall was estimated in Section 3.1.1.1 as $2x10^{-15}$ m². To account for uncertainty, a range of permeability of four orders of magnitude for the explosion isolation wall was selected from 10^{-17} m² to 10^{-13} m².

The run of mine salt backfill is placed in a loose state in the air-intake and air-exhaust drifts of each panel. Case et al. (1987) reports on an experiment on WIPP crushed salt that measured the relationship of hydraulic conductivities to porosity when subjected to confining pressure. The test results showed that the intrinsic permeability might equal 0.01 darcy (10^{-14} m^2) at 15 percent porosity. For high porosities from 35 to 40 percent, the test results showed that the intrinsic permeability might equal 10^2 darcy (10^{-10} m^2) . Therefore, the range of intrinsic permeability is selected from 10^{-14} m^2 to 10^{-10} m^2 .

3.1.3.1 Evaluation Procedure

In order to combine information on assessing the mass flow rate of carbon tetrachloride from a single panel, MathConnex (MathSoft, Inc., 1999) was used. MathConnextm is an environment for visually integrating and linking applications and data sources to create heterogeneous computational systems. MathConnex provides a means of connecting MathCad and EXCEL files together in a network. In the MathConnex file entitled Monte Carlo Simulation for Restricted Flow, the uncertain parameters are implemented in four MathConnex components:

- Headspace Concentration of CCl₄ is an EXCEL file that generates a random sample for the headspace concentration of carbon tetrachloride as discussed above.
- Volumetric Closure Rate is an EXCEL file that generates a random sample of the panel volumetric closure rate as discussed above.
- Gas Generation Rate is an EXCEL file that generates a random sample of the gas generation rate as discussed above.
- Intrinsic Permeabilities is an EXCEL file that generates a random sample of the intrinsic permeabilities for each of the flow components as discussed above.

For a single realization of the randomly sampled parameters, the outputs from each of these components is input to the MathCad file entitled Restricted Flow Model. The restricted flow model is used to develop a time history for the mass flow rate of CCl₄ out of the panel. The output from the Restricted Flow Model is then input to an EXCEL file Monte Carlo Simulation. This file develops the time histories for multiple realizations of the input parameters.

3.1.3.2 Modeling Results

A Monte Carlo Simulation was performed for the restricted flow analysis of VOCs. The results of this simulation for 40 different realizations are presented in Figure 3-5. The figure shows the variation of mass flow rate for carbon tetrachloride during the operational life of the WPC. The mass flow rate limit for CCl₄ is calculated as the mass concentration limit at E-300 drift times the minimum underground ventilation flow rate of 260,000 ft³/min (7,362 m³/min) required by HWFP.

In general, the magnitude of the unrestricted steady-state mass flow rate of CCl₄ reflects the uncertainty in VOCs concentration rates, panel gas generation rate, and panel volumetric closure rate. The time required to reach the restricted steady-state VOC mass flow rate depends on the intrinsic permeability of the flow components. In some restricted realizations, the mass flow rate rises rapidly to the unrestricted steady-state mass flow rate, so the flow is essentially unrestricted. In the large majority of cases, however, the WPC offers some resistance to flow and the mass flow rates develop much more slowly. In all cases the WPC complies with the mass flow rate limit at the E-300 drift as required by HWFP.

3.2 Analyses Addressing Material and Structural Requirements

This section presents evaluations relating to the material and structural requirements for the WPC.

3.2.1 Material Compatibility Evaluation

The purpose of the material compatibility evaluations is to select suitable materials for the WPC. The materials must be chemically compatible with the host rock and brine without chemical degradation. This section presents information on brine-cement interactions at the locations of the WPC.

WIPP brines were initially studied when evidence of some minor concrete deterioration in the Waste Shaft key was noted (DOE, 1996a). The cause was geochemical alteration of the concrete shaft liner and shaft grout by the brine present at the Rustler-Salado contact. Chemical constituents detected in brine samples included both organic and inorganic compounds that probably originated from dissolution of the concrete liner and grout materials used in the shaft construction. The presence of large amounts of organics that likely originated from the chemical grout appeared to have complexed the calcium present in the brine, interfering with the inorganic chemistry of the naturally occurring brine. The brines in contact with the Waste Shaft key were

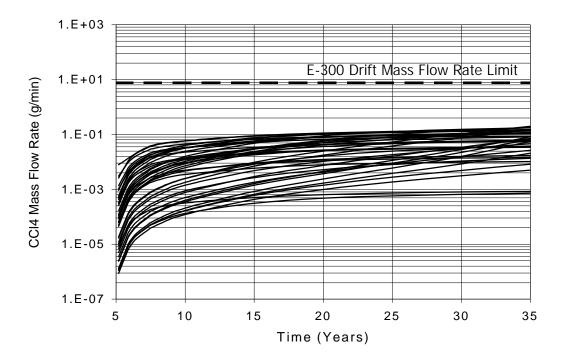


Figure 3-5 Mass Flow Rate for Carbon Tetrachloride

also found to be significantly higher in both chlorides and magnesium than the Salado Formation brine.

Several other studies investigated the effect of the high-magnesium brine interactions on various candidate barrier materials (DOE, 1996a). However, the original PCS design concluded that two extremely different service environments can be inferred between the Waste Shaft key and the underground repository horizon.

The WPC consists of concrete block wall and run of mine salt backfill. Blocks will be pre-cast in a factory setting and no organic grout compounds are used in the design. The magnesium level in the brines is much lower at the repository horizon. Further, only trace amounts of brine would contact the explosion isolation wall over the operational period due to the relative impermeability of the surrounding halite. For these reasons, significant brine-cement interactions are not anticipated and the block walls will perform their function within this time period. Run of mine salt backfill is entirely compatible with the underground environment.

3.2.2 Heat Generation

The WPC uses concrete blocks for explosion isolation wall. The concrete blocks will be pre-cast and cured in a factory setting. They will then be transported to the site and taken underground as convenient. Note that for these small blocks (8x8x16 inches), the volume to surface ratio is smaller than for large monolithic emplacements of concrete. Thus the temperature rise due to the heat of hydration can be dissipated without the development of tensile strains within the blocks before emplacement. Quality control testing of the blocks will assure strength and serviceability. Therefore cement heat generation is not an issue for the WPC.

3.2.3 Explosion Evaluations

The evaluation of the postulated methane explosion consists of evaluating the pressure and thermal effects of such an explosion on the explosion isolation wall. A methane explosion would generate an initial pressure transient that would impinge on the explosion isolation wall. Subsequently, temperature would rise in the panel as well as in the explosion isolation wall.

Two analyses are necessary to evaluate methane-explosion effects: (1) effect of explosion pressure, and (2) effect of explosion heat. After an explosion, the explosion isolation wall would be subjected to short-term dynamic loading. The design pressure can be calculated as the maximum pressure times the dynamic load factor (Biggs, 1964). The dynamic load factor will

depend on the shape of the pressure-time transient. An explosion will result in a transient pressure pulse that will rise instantaneously and then drop gradually.

The second effect requires a thermal analysis with a heat-transfer model. The results of the heat transfer model calculations (DOE, 1996a) are valid under the postulated explosion. The heat transfer model under the postulated explosion within the panel considered the heat balance between the gas and the walls of the panel for a stoichiometric mixture of methane. The rate at which the gas temperature will rise within the panel depends on (1) the number of moles of methane, (2) the specific heat capacity of the gas and the heat transfer to the salt and the walls through radiation, (3) convection along the vertical and horizontal surfaces, and (4) conduction within the salt and walls. The thermal analysis result (DOE, 1996a) showed that the elevated temperature due to explosion would propagate a maximum of 6 inches (15 cm) through the wall.

In the event of a hydrocarbon explosion either (1) deflagration will result in a rapid rise of pressure, with no transition to a detonation, or (2) a detonation wave front will propagate as a supersonic shockwave. The transition to a detonation is a function of two parameters: (1) the methane concentration at the time of the explosion, and (2) the ability for a wave front to form. In underground excavations, the latter condition typically requires a reasonably long passage through which the combustion wave travels and transforms to a detonation. The probability of occurrence of a detonation in an air-gas mixture also depends strongly upon the type of air-gas mixture. In the case of WIPP, the open passages above the waste stack will reduce in size due to creep closure so it is unlikely that a long passage with open geometry will exist. As a result the occurrence of detonation in underground excavation at WIPP is very unlikely. Therefore this analysis will only consider deflagration.

The peak explosive pressure arising from a deflagration is about eight times (DOE, 1996a) the ambient pressure at the time of explosion. The ambient pressure at the time of explosion depends on panel volume reduction rate, gas flow rate from WPC, and gas generation rate. In the current analysis the ambient pressure will reach a steady value of 1.41 atmosphere in a short time after panel closure. This results in a peak explosion pressure of 164 psi (1.14 MPa).

The dynamic load factor will depend on the natural frequency of the explosion isolation wall. The value for the dynamic load factor approaches a maximum value of 2, with increased natural frequency for a variety of exponential curves (DOE, 1996a). Based upon this loading, the block wall will be subjected to an equivalent uniform pressure of 328 psi (2.28 MPa). The result of the stress analysis is presented in the next section.

3.2.4 Stress Analysis

The purpose of the stress analysis was to evaluate the interaction of the block wall and run of mine salt backfill of the WPC with the surrounding salt. Stresses are expected to develop in the block wall component due to continued creep closure of the air-intake and air-exhaust drifts after installation of the block wall. Stresses are also expected to develop in the run of mine backfill, although at a very much slower rate than in the block wall. It is also shown that each component can individually withstand the postulated methane explosion.

3.2.4.1 Block Wall Evaluation

Detailed two-dimensional axisymmetric representations of the WPC were developed using the FLAC (Itasca, 2000) computer code. The properties used in these models are presented in Appendix C.

FLAC has been used since 1991 to model underground excavations at the WIPP. FLAC is a two-dimensional explicit finite difference code that simulates the behavior of rock and soil-like structures. The WIPP Reference Creep Law is built into the code and has been verified against the WIPP Second Benchmark Problem (Kreig, 1984). The following sections describe the geometry and boundary conditions of the models used in the FLAC analysis.

Model Development. A detailed axisymmetric model was developed to investigate the barrier under creep loading and combined creep and explosion loading. The geometry of this model is shown in Figure 3-6. There are five construction joints in this case, which are spaced evenly in the block wall. The construction joints have no cohesion (see Appendix C). The concrete is modeled as a Mohr-Coulomb material with a tension cut-off. Three cases were run with different loading and strength properties as called for by the ACI Ultimate Strength Design Method (ACI 318-02):

$$1.2 W + 1.6 E$$

$$0.9 W + 1.6 E$$

where W and E denote the dead load (far-field stress) and explosion load, respectively. All three cases used a strength reduction factor of 0.8. In addition to these three cases, a service load case

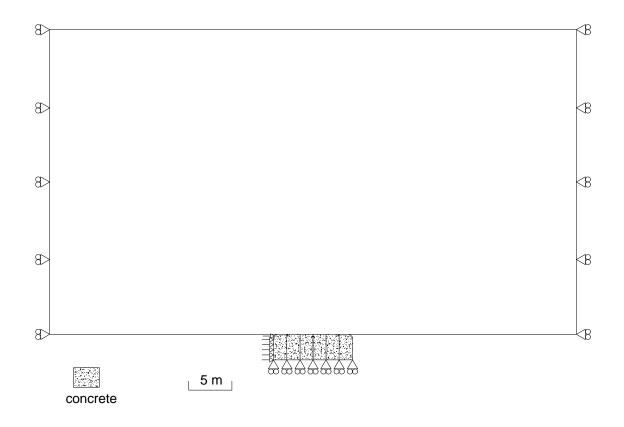


Figure 3-6 Creep Plus Explosion Model Geometry and Boundary Conditions

was run with all loading and strength properties set to their nominal values. In all cases with an explosion load, the explosive force was applied instantaneously, equilibrium was reached, and then the force was removed.

Modeling Results. The results from the ultimate strength design cases showed that while some compressive failure occurs near the ends of the block wall, the wall maintains a sizable intact confined core in every case, thus validating the design. Only the results from the service load case are presented here. Profiles of the stress in the block wall caused by an explosion after ten years of creep loading are shown in Figure 3-7 and Figure 3-8. The vertical (radial) loading is not significantly changed, while the axial loading is actually improved since the stress goes slightly compressive rather than tensile. Figure 3-9 and Figure 3-10 show contours of stress in the wall and in the rock during the explosion. Figure 3-11 shows the plasticity state in the wall at 35 years. This figure shows a limited tensile fracture zone near the rocksalt-concrete interface. Like the construction joints, these fractures are normal to the direction of the VOC flow through the WPC and have minimal impact on the flow conductance. Figure 3-12 shows a vertical stress profile in the block wall at 35 years, the required design life. These figures show that the block wall will perform its required function throughout the nominal operational design life.

3.2.4.2 Run of Mine Salt Backfill Evaluation

The run of mine salt backfill also provides a barrier to resist explosion pressure. To show the effectiveness of the salt backfill as an explosion barrier, a simple analytical model was developed. The following simplifying assumptions were made to conduct a conservative analysis.

- The run of mine backfill was subjected to all of the explosion loading.
- The explosion pressure is assumed to reach the maximum value of 1.14 MPa (Section 3-2-3) instantly and remains constant with negligible decay.
- The confining pressures on the salt backfill due to creep closure of the surrounding rocksalt are ignored.
- The geometric and material dampings are ignored.
- The only resistance mechanism is the frictional contact between backfill and rocksalt.
- Backfill material is assumed to be elastic.

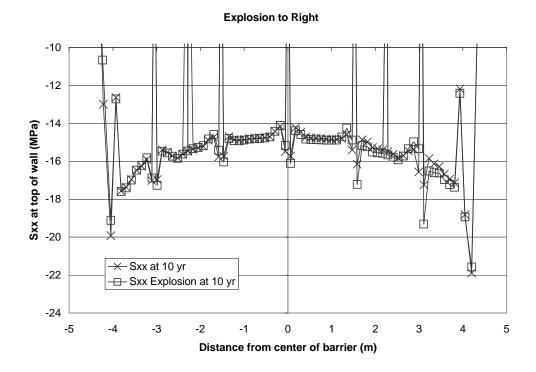


Figure 3-7 Vertical (Radial) Stress Profile at Top of Block Wall During an Explosion Occurring 10 Years after Emplacement

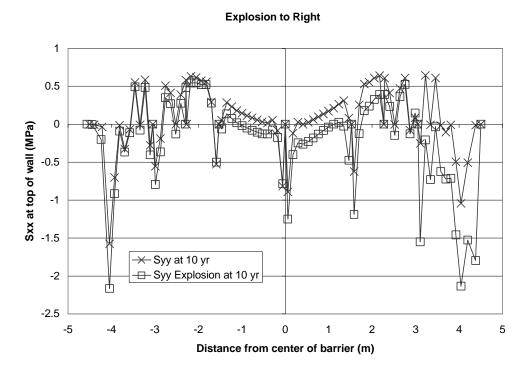


Figure 3-8 Horizontal (Axial) Stress Profile at Top of Block Wall During an Explosion Occurring 10 Years after Emplacement

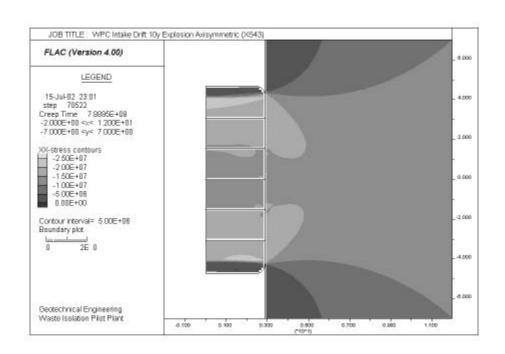


Figure 3-9 Vertical (Radial) Stress Contours in Block Wall During an Explosion Occurring 10 Years after Emplacement

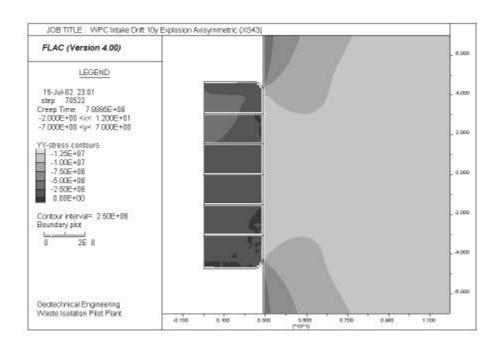


Figure 3-10 Horizontal (Axial) Stress Contours in Block Wall During an Explosion Occurring 10 Years after Emplacement

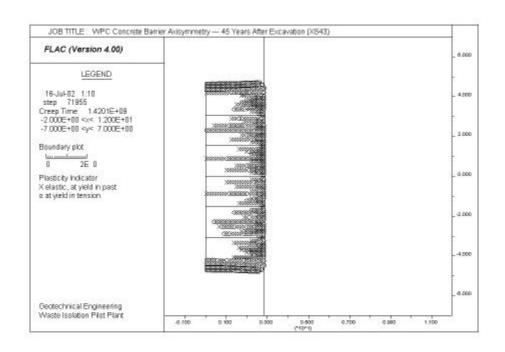


Figure 3-11 Plasticity State in Block Wall at 35 Years

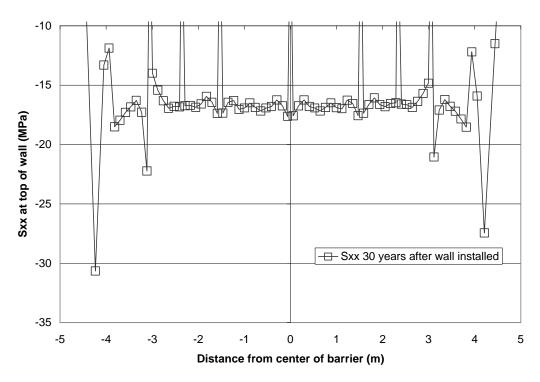


Figure 3-12 Vertical (Radial) Stress Profile at Top of Block Wall at 35 Years

The strain-stress relations for a general three-dimensional body can be written as (Fung, 1965):

$$\begin{cases}
\mathbf{e}_{x} = \frac{\mathbf{s}_{x}}{E} - \mathbf{u} \frac{\mathbf{s}_{y}}{E} - \mathbf{u} \frac{\mathbf{s}_{z}}{E} \\
\mathbf{e}_{y} = \frac{\mathbf{s}_{y}}{E} - \mathbf{u} \frac{\mathbf{s}_{x}}{E} - \mathbf{u} \frac{\mathbf{s}_{z}}{E} \\
\mathbf{e}_{z} = \frac{\mathbf{s}_{z}}{E} - \mathbf{u} \frac{\mathbf{s}_{x}}{E} - \mathbf{u} \frac{\mathbf{s}_{y}}{E}
\end{cases}$$
(Equation 3-7)

where \mathbf{s}_x , \mathbf{s}_y and \mathbf{s}_z are the normal stress components in the x, y and z directions, respectively, \mathbf{e}_x , \mathbf{e}_y and \mathbf{e}_z are the corresponding normal strain components, and E and \mathbf{n} are the Young's modulus and Poisson's ratio respectively.

By taking the x axis as the longitudinal axis along the salt backfill $(0 < x < \infty)$ and setting $\mathbf{e}_y = \mathbf{e}_z = 0$, Equation 3-7 reduces to the following one-dimensional form:

$$\boldsymbol{e}_{x} = (1 - 2\boldsymbol{u} K_{o}) \frac{\boldsymbol{s}_{x}}{E}$$
 (Equation 3-8)

where

$$K_O = \frac{\mathbf{u}}{1 - \mathbf{u}}$$

By substituting Equation 3-8 into the one-dimensional strain-displacement relation of $\mathbf{e}_x = du/dx$ and defining $\mathbf{s}_x = -p$ one obtains:

$$\frac{du}{dx} = -\left(1 - 2\mathbf{u}\,K_o\right)\frac{p}{E} \tag{Equation 3-9}$$

where u = u(x,t) is the axial displacement along the x axis at time t.

The applied forces on a longitudinal backfill element of length dx are shown in Figure 3-13. Equilibrium of these forces along the x axis results in:

$$p A = r \frac{\partial^2 u}{\partial t^2} A dx + (p + dp) A + \mathbf{m} K_o \quad p Q dx \qquad (u, x, t > 0)$$
 (Equation 3-10)

in which:

r = mass density

 \mathbf{m} = coefficient of friction

A = cross-sectional area of backfill

Q = perimeter of backfill in cross section

$$r \frac{\partial^2 u}{\partial t^2} A dx$$
 = inertia force

 $\mathbf{m} K_o p Q dx$ = friction force along the perimeter of backfill

Using Equation 3-9, Equation 3-10 can be further simplified as:

$$C^{2} \frac{\partial^{2} u}{\partial x^{2}} - \frac{\partial^{2} u}{\partial t^{2}} + 2 \mathbf{1} C^{2} \frac{\partial u}{\partial x} = 0 \qquad (u, x, t > 0)$$
 (Equation 3-11)

where

$$C = \sqrt{\frac{E}{r (1 - 2\mathbf{u} K_o)}}$$

$$\boldsymbol{l} = \frac{K_o \, \boldsymbol{m} \, Q}{2A}$$

Equation 3-11 is subjected to zero displacement and velocity as initial conditions. Also, from Equation 3-9, the following boundary condition is applied:

$$\frac{\partial u}{\partial x}(0,t) = -\frac{\left(1 - 2\mathbf{u} K_o\right)}{E} P(t)$$
 (Equation 3-12)

where P(t) is the explosion pressure at the explosion face. By ignoring the reflected wave effect from the far end of the backfill, Equation 3-11 is solved using the central finite difference method. The elastic parameters for run of mine salt (E = 20.1 MPa, u = 0.25) were adopted from Callahan and DeVries (1991). A conservative value of 25 degrees similar to loose silt or silty sand (Bowls, 1982) was used for the friction angle of run of mine salt.

Figure 3-14 shows the result of the analysis. Based on this figure, the displacement of the salt at the explosion face is 13.8 inches (0.350 m) when the maximum displacement at the opposite end is about 0.4 inches (0.01 m). This verifies that the run of mine salt backfill performs as an effective explosion barrier.

3.2.5 Fracture-Propagation Evaluation

The fracture-propagation studies evaluate the potential for fracture propagation, using the results of previous analyses. The results of the thermal analysis suggest that elevated temperatures within an explosion isolation wall and salt will be a localized phenomenon. During an explosion two phenomena could affect the potential fracturing of the salt: (1) the expansion of the explosion products into existing fractures, and (2) the potential reflection of sonic waves off free surfaces around the barrier. The fractures in the roof and floor could be affected by the expansion of the gas products on the order of 164 psi (1.14 MPa), which decay rapidly with time and attenuate with distance. Around the wall, the confining stress on the order of 2,100 psi (15 MPa) will develop. Horizontal fracture propagation could occur around the barrier only if the internal gas pressure exceeds confining pressure. Because the peak internal pressure from deflagration is less than ten percent of the confining pressure, fractures would not propagate through or around the main wall.

Following an explosion, the wall would be subject to sonic waves that would impinge on the wall. As the sonic wave encounters a contrast in wall stiffness, a portion of the sonic wave would be refracted, and a portion would be reflected (Jaeger and Cook, 1972). This would result in minor tensile spalling of the isolation wall. The salt backfill causes a partial wave transmission and damping which in turn reduces the reflected tensile wave. At the time of a potential explosion, the development of confining stress relative to the explosion pressure would prevent fracturing around the block wall. The block wall can safely withstand the pressure from the postulated methane gas explosion.

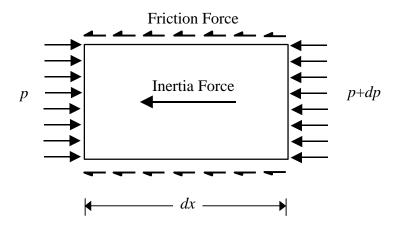


Figure 3-13 Applied Forces on a Longitudinal Element of Backfill

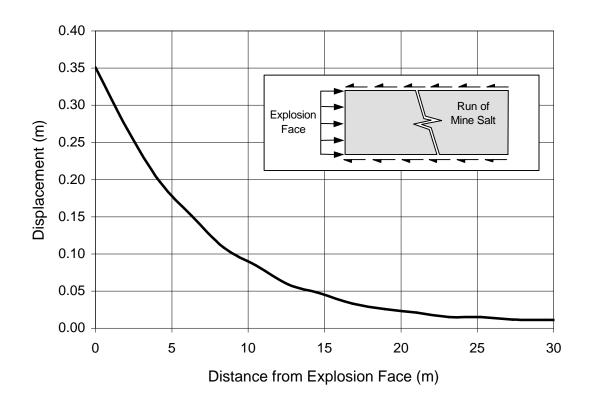


Figure 3-14 Dynamic Displacement versus Distance from Explosion Face

4.0 Design Calculations

All calculations were performed in accordance with the RockSol Consulting Group, Inc., Quality Assurance Program and comply with Westinghouse TRU Solutions requirements. The documentation for the codes and calculations, as well as related documents such as verification and validation tests, constitute quality records and are maintained in accordance with WIPP procedures.

The bases for all calculations are presented in Chapter 3 and Appendices A, B, and C. All software for the design calculations have been documented, verified and validated in accordance with the RockSol Consulting Group, Inc. Quality Assurance Program. This program complies with the requirements of the Westinghouse TRU Solutions QA Program.

5.0 Technical Specifications

The specifications are in the engineering file room at the WIPP and are the property of Westinghouse. These specifications are included as an attachment in Appendix D and are summarized in Table 5-1.

Table 5-1 Technical Specifications for the WIPP Panel Closure System

Division 1 - General Requirements		
Section 01010	Summary of Work	
Section 01090	Reference Standards	
Section 01400	Contractor Quality Control	
Section 01600	Material and Equipment	
Division 2 - Site Work		
Section 02010	Mobilization and Demobilization	
Section 02222	Excavation	
Division 3 - Masonry		
Section 03100	Mortar	
Section 03300	Unit Masonry System	
Section 03400	Masonry Explosion Isolation Structure	
Division 4 - Salt Backfill		
Section 04100	Salt Backfill	

6.0 Drawings

The Drawings (Appendix E) are in the engineering file room at the WIPP and are summarized in Table 6-1.

Table 6-1 WIPP Panel Closure System Drawings

Drawing Number	Title
110-CD001	Panel closure system, title sheet
110-CD002	Panel closure system, underground waste disposal panel
110-CD003	Panel closure system, construction details

7.0 Conclusions

This chapter presents the conclusions for the detailed design activities for the WPC. Table 7-1 shows the performance specifications for the WPC and the compliance of the design with the performance specifications. The design configuration and essential features for the WPC include an explosion isolation wall constructed of 5000 psi (34.5 MPa) unconfined compressive strength blocks that is 30 ft (9.1 m) long, and a run of mine salt backfill section that is 100 ft (30.5 m) long. Surface treatment around the explosion isolation wall includes the removal of loose material to create a clean, regular surface for construction of the block wall.

The design is presented in this report as performance specifications, a series of calculations, and engineering Drawings and Specifications. Structural analyses used to select the design length and other design features are based upon data acquired from the WIPP underground. The Drawings illustrate and describe the construction and details for the system. The Specifications cover the general requirements of the system, quality assurance and quality control, site work, masonry, and run of mine salt backfill. Information on the proposed construction method is also presented. The WPC can be built to generally-accepted national design and construction standards.

The design complies with all aspects of the design basis established for the WPC. The design can be constructed in the underground environment with no special requirements at the WIPP. To investigate several key design issues and to implement the design, design evaluations were performed. The conclusions reached from the evaluations are as follows:

- The mass flow rates for different VOCs through the WPC (including flow through the DRZ, the explosion isolation wall, and run of mine salt backfill) are substantially below the limits established in the HWFP for the E-300 drift.
- The Monte Carlo Simulation Method was used to assess the uncertainty of VOCs headspace concentrations, gas generation rates, and panel volume closure rates on the mass flow rate of carbon tetrachloride. The time required to reach the steady-state mass flow rate of carbon tetrachloride depends on the intrinsic permeability of the flow components. In some realizations the mass flow rate rises rapidly to the steady-state mass flow rate and the flow is essentially unrestricted. In most cases, however, the WPC offers resistance to flow, and mass flow rates would develop more slowly. In all cases, the explosion isolation wall with the run of mine salt backfill complies with the mass flow rate limit at the E-300 drift.
- The passive design components of the WPC do not require routine maintenance during the

nominal operational life of 35 years.

- Thermal cracking due to heat of hydration effects does not apply to concrete blocks.
- The trace amounts of brine from the salt at the repository horizon would not degrade the main concrete barrier for at least 35 years.
- Detailed axisymmetric models were developed to assess the state of stress in the block wall
 and surrounding rock due to creep closure of the salt. The length selected for the explosion
 isolation wall provides for a substantial margin of safety against structural failure due to
 creep loading.
- Stress analysis shows that the wall will withstand both the forces of creep and the postulated methane explosion. Further, at the time of a potential explosion, the development of confining stress would prevent fracturing around the block wall.
- The heat-transfer analysis in the previous PCS design (DOE, 1996a) showed that elevated temperatures would occur within the salt and the explosion isolation wall; however, the elevated temperatures will be isolated by the PCS. Temperature gradients will not significantly affect the stability of the wall.
- The WPC provides for flexibility over the 35-year operational life in construction scheduling and construction material transportation and therefore minimizes the effect on waste receipt.

In addition to the design requirements presented above, the design includes a QA/QC program to verify material properties and construction practices. The existing shafts and underground access can accommodate the construction of the WPC.

Table 7-1 Compliance with Performance Specifications

Requirement	Design Report Section	Compliance with Requirement	Notes on Compliance
The panel closure system design shall limit VOC migration from a closed panel consistent with the limits found in Table IV.F.2.c of the HWFP.	3.1	Complies	Gas-flow modeling shows that the VOC flow is substantially less than the E-300 drift limit specified in the HWFP.
The panel closure system shall consider potential flow of VOCs through the disturbed rock zone (DRZ) in addition to flow through closure components.	3.1	Complies	Restricted gas-flow model considers flow through the DRZ.
The panel closure system shall perform its intended functions under loads generated by creep closure of the tunnels.	3.2.4	Complies	Stress analyses and design calculations show that the WPC performs as intended under creep closure.
The panel closure system shall perform its intended function under the conditions of a postulated methane explosion.	3.2.3 3.2.4 3.2.5	Complies	The methane explosion studies, fracture propagation studies, and supporting design calculations show that the WPC performs as intended.
The nominal operational life of the closure system is thirty-five (35) years.	3.1 3.2	Complies	Gas-flow modeling and stress analyses shows satisfactory performance for 35 years.
The panel closure system for each individual panel shall not require routine maintenance during its operational life.	2.2	Complies	Passive design components require no routine maintenance.
The panel closure system shall address the most severe ground conditions expected in the waste disposal area.	3.1 3.2	Complies	Design is based upon flow and structural analyses of the most severe ground conditions.
The design class of the panel closure system shall be IIIb (which means that it is to be built to generally accepted national design and construction standards).	2.3	Complies	The construction sequence for the design followed conventional mining practices.
The design and construction shall follow conventional mining practices.	2.2 2.3	Complies	The specifications include normal construction practices used in the underground at WIPP and according to the most current mortar and concrete block specifications.

Table 7-1 (Continued) Compliance with Performance Specifications

Requirement	Design Report Section	Compliance with Requirement	Notes on Compliance
Structural analysis shall use data acquired from the WIPP underground.	3.2.4	Complies	The structural analysis uses properties that model creep closure for stress analyses from data acquired in the WIPP Geotechnical Monitoring Program.
Materials shall be compatible with their emplacement environment and function.	3.2.1	Complies	The material compatibility studies showed no degradation of materials and no need for surface treatment.
Treatment of surfaces in the closure areas shall be considered in the design.	Appendix D	Complies	Design specifications address surface treatment
Thermal cracking of concrete shall be addressed.	3.2.2	Complies	Thermal cracking due to heat of hydration effects do not apply to concrete blocks.
During construction, a Quality Assurance/Quality Control (QA/QC) program shall be established to verify material properties and construction practices.	Appendix D	Complies	The specifications include materials testing to verify material properties and construction practices.
Construction of the panel closure system shall consider shaft and underground access and services for materials handling.	Appendix D	Complies	The specifications allow construction within the capacities of underground access.

8.0 References

American Concrete Institute (ACI), 2002, "Building Code Requirements for Structural Concrete and Commentaries," *ACI 318-02*, American Concrete Institute, Farmington Hills, Michigan.

American Concrete Institute (ACI), 2002, "Building Code Requirements for Masonry Structures & Specification for Masonry Structures & Commentaries," *ACI 530.1-02*, American Concrete Institute, Farmington Hills, Michigan.

American Society for Testing and Materials (ASTM), 2002, "Standard Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation," *ASTM C* 1077-02, American Society for Testing and Materials, West Conshohocken, Pennsylvania.

American Society for Testing and Materials (ASTM), 2002, "Standard Practice for Agencies Performing Nondestructive Testing," *ASTM E 543-02*, American Society for Testing and Materials, West Conshohocken, Pennsylvania.

American Society for Testing and Materials (ASTM), 2002, "Standard Specification for Aggregate for Masonry Mortar," *ASTM C 144-02*, American Society for Testing and Materials, West Conshohocken, Pennsylvania.

American Society for Testing and Materials (ASTM), 2002, "Standard Specification for Portland Cement," *ASTM C 150-02*, American Society for Testing and Materials, West Conshohocken, Pennsylvania.

American Society for Testing and Materials (ASTM), 2002, "Standard Test Method for Compressive Strength of Masonry Prisms," *ASTM C 1314-02a*, American Society for Testing and Materials, West Conshohocken, Pennsylvania.

American Society for Testing and Materials (ASTM), 2002, "Standard Test Method for Preconstruction and Construction Evaluation of Mortars for Plain and Reinforced Unit Masonry," *ASTM C* 780-02, American Society for Testing and Materials, West Conshohocken, Pennsylvania

American Society for Testing and Materials (ASTM), 2002, "Standard Test Methods for Sampling and Testing Concrete Masonry Units and Related Units," *ASTM C 140-02*, American Society for Testing and Materials, West Conshohocken, Pennsylvania.

American Society for Testing and Materials (ASTM), 2001, "Standard Practice for Accreditation of Testing Agencies for Unit Masonry," *ASTM C 1093-95*, American Society for Testing and Materials, West Conshohocken, Pennsylvania.

American Society for Testing and Materials (ASTM), 2001, "Standard Specification for Extended Life Mortar for Unit Masonry," *ASTM C 1142-95*, American Society for Testing and Materials, West Conshohocken, Pennsylvania.

American Society for Testing and Materials (ASTM), 2001, "Standard Specification for Concrete Brick," *ASTM C 55-01a*, American Society for Testing and Materials, West Conshohocken, Pennsylvania.

American Society for Testing and Materials (ASTM), 2001, "Standard Specification for Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction," *ASTM E 329-01a*, American Society for Testing and Materials, West Conshohocken, Pennsylvania.

American Society for Testing and Materials (ASTM), 2001, "Standard Specification for Mortar for Unit Masonry," *ASTM C 270-01a*, American Society for Testing and Materials, West Conshohocken, Pennsylvania.

American Society for Testing and Materials (ASTM), 2001, "Standard Specification for Masonry Cement," *ASTM C 91-01*, American Society for Testing and Materials," West Conshohocken, Pennsylvania.

American Society for Testing and Materials (ASTM), 2000, "Standard Specification for Ready-Mixed Concrete," *ASTM C 94-00*, American Society for Testing and Materials, West Conshohocken, Pennsylvania.

American Society for Testing and Materials (ASTM), 1997, "Standard Specification for Hydrated Lime for Masonry Purposes," *ASTM C 207-91*, American Society for Testing and Materials, West Conshohocken, Pennsylvania.

American Society for Testing and Materials (ASTM), 1994, "Standard Guide for General Criteria Used for Evaluating Laboratory Competence," *ASTM E 548-94*, American Society for Testing and Materials, West Conshohocken, Pennsylvania.

Biggs, J., 1964, Introduction to Structural Dynamics, McGraw Hill, New York, New York.

Bowles, E., 1982, Foundation Analysis and Design, McGraw-Hill, New York, New York.

Callahan, G. D., and K. L. DeVries, 1991, "Analyses of Backfilled Transuranic Wastes Disposal Rooms," *SAND91-7052*, Sandia National Laboratories, Albuquerque, New Mexico.

Case, J. B., and P. C. Kelsall, 1986, "Shaft-Seal Modeling and Analysis of the Small Scale Seal Performance Tests at the Waste Isolation Pilot Plant," IT Corporation, Albuquerque, New Mexico.

Case, J. B., P. C. Kelsall, and J. L. Withiam, 1987, "Laboratory Investigation of Crushed Salt Consolidation," *Rock Mechanics: Proceedings of the 28th US Symposium*, Edited by: I. W. Farmer, J. J. K. Daemen, C. S. Desai, C. E. Glass, and S. P. Neuman, Tucson, Arizona, pp189-196.

Daemen, J. J. K., J. C. Stormont, N. I. Colburn, D. L. South, S. A. Dischler, K. Fuenkajorn, W. Greer, G. S. Adisoma, D. E. Miles, B. Kousari, and J. Bertucca, 1983, "Rock Mass Sealing Experimental Assessment of Borehole Plug Performance," *NUREG/CR3483*, University of Arizona, Tucson Arizona.

Fernandez, J. A., J. B. Case, C. A. Givens, and B. C. Camey, 1994, "A Strategy to Seal Exploratory Boreholes in Unsaturated Tuff," *SAND93-1184*, Sandia National Laboratories, Albuquerque, New Mexico.

Freeze, A., and J. Cherry, 1979, *Groundwater*, Prentice Hall, Inc., Englewood Cliffs, New Jersey.

Fung, Y. C., 1965, *Foundations of Solid Mechanics*, Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

Hahn, G. J., and S. S. Shapiro, 1967, *Statistical Models in Engineering*, John Wiley & Sons, New York, New York.

IT Corporation (IT), 1994, "Backfill Engineering Analysis Report," report prepared for Westinghouse Electric Corporation, Carlsbad, New Mexico.

Itasca Consulting Group, Inc. (Itasca), 2000, "FLAC User's Manual," Itasca Consulting Group, Inc., Minneapolis, Minnesota.

Jaeger, J. C., and N. G. W. Cook, 1972, *Fundamentals of Rock Mechanics*, John Wiley and Sons, New York, New York.

Krieg, R. D., 1984, "Reference Stratigraphy and Rock Properties for the Waste Isolation Pilot Plant," *SAND83-1908*, Sandia National Laboratories, Albuquerque, New Mexico.

Lindeburg, M. R., 1986, Civil Engineering Reference Manual, Professional Publications, Inc.

MathSoft, 1999, Mathcad 2000 User's Guide, MathSoft, Inc., Cambridge Massachusetts.

Mine Safety and Health Administration (MSHA), 2002, "Safety Standards for Methane in Metal and Nonmetal Mines," *Title 30, Code of Federal Regulations (CFR), Part 57 (30 CFR 57)*, U.S. Department of Labor, Mine Safety and Health Administration, Washington, D.C.

New Mexico Environment Department, 2000, "Adoption of 40 CFR Part 264," *Title 20 (Environmental Protection) of the New Mexico Administrative Code, Chapter 4 (Hazardous Waste), Part 1 (Hazardous Waste Management)*, New Mexico Hazardous and Radioactive Materials Bureau, Santa Fe, New Mexico.

Portland Cement Association (PCA), 2002, "Fundamentals of Concrete," *ISO54*, Portland Cement Association, Skokie, Illinois.

U.S. Department of Energy (DOE), 1996a, "Detailed Design Report for an Operational Phase Panel Closure System," *DOE/WIPP 96-2150*, U.S. Department of Energy, WIPP Project Office, Carlsbad, New Mexico.

U.S. Department of Energy (DOE), 1996b, "WIPP Compliance Certification Application 40 CFR 191 Subpart B and C." CD-ROM Version prepared by the Carlsbad Technical Assistance Contractor, Roy F. Weston, Carlsbad, New Mexico.

U.S. Department of Energy (DOE), 1995, "Conceptual Design for Operational Phase Panel Closure Systems," *DOE-WIPP-95-2057*, U.S. Department of Energy, WIPP Project Office, Carlsbad, New Mexico.

U.S. Department of Energy (DOE), 1994, "Panel 1 Utilization Plan." *WIPP/WID-94-2027*, Westinghouse Electric Corporation, Carlsbad, New Mexico.

U.S. Environmental Protection Agency (EPA), 2001, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," *Title 40 (Protection of Environment) of the Code of Federal Regulations, Part 264*, U.S. Government Printing Office.

WIPP Waste Information System, 2002, "Headspace Gas Concentration Report," Report RP0430, 4/25/2002.

WIPP Hazardous Waste Facility Permit, NM 4890139088-TSDF, Aug. 31, 2001, Module IV - Geologic Repository Disposal.

Westinghouse TRU Solutions, 2002, "Mining/Emplacement Schedule," June 1st 2002 update.

APPENDIX A DERIVATION OF RELATIONSHIPS FOR THE AIR-FLOW MODELS

APPENDIX A DERIVATION OF RELATIONSHIPS FOR THE AIR-FLOW MODELS

A.1.0 Introduction

This appendix presents the derivation of unrestricted and restricted air-flow models used to determine the performance of the panel closure system. These derivations were used in the analyses in Section 3.1 to determine gas flow from a panel. These analyses provide an estimate of the volume of gas that might flow through the panel closure systems at the Waste Isolation Pilot Plant (WIPP).

A.2.0 Model for Unrestricted Flow of VOCs

A model for the unrestricted flow of volatile organic compounds (VOCs) was developed to predict the mass flow rates of VOCs and to compare these mass flow rates with the design migration limits for VOCs. Over time, a mixture of gases containing VOCs flows from each waste container. It is assumed for the unrestricted flow model that the headspace concentrations serve as a constant source of VOCs. This assumption is conservative because most containers only have trace quantities of VOCs, either trapped in the headspace or on the surfaces of the various waste components. It is likely that only a small number of waste containers have a significantly greater source of VOCs such as a solvent-soaked rag. Only this small number of waste containers have a realistic likelihood of maintaining a constant headspace VOC concentration as gas generation proceeds.

The VOCs originating from the waste containers can migrate from the panel due to volumetric creep closure of the panel void space and to gas generation due to microbial degradation of the waste. Because flow is unrestricted, the VOCs migrate under a pressure of one atmosphere. Other assumptions in the unrestricted flow model are as follows:

- Any gases released into the mine atmosphere would be reduced in concentration by the
 minimum ventilation rate of 260,000 ft³/min (7,362 m³/min) required by HWFP at E-300
 drift. The mass flow rate of individual VOCs from individual panels following their
 closure is summed to determine the mass flow rate of VOCs at E-300 drift.
- The analysis uses the schedule for closure of individual panels (Westinghouse, 2002) as illustrated in Table A-1 during the operational life of the panel closure system.

 Open panels of waste are not considered as a source contributing to the emissions of VOCs.

Considering only advection in the migration of VOCs, the mass-balance relationship is (DOE, 1996):

$$C_p \cdot Q_p = C_{E300} \cdot Q_{E300}$$
 (Equation A-1)

where

 C_n = Headspace concentration for an individual VOC

 Q_p = Flow rate of VOCs from the panel

 C_{E300} = Concentration of VOCs at the E-300 drift

 Q_{E300} = Underground ventilation flow rate at the E-300 drift

Table A-2 presents the maximum headspace concentrations for different VOCs of concern. The total flow rate of VOCs from the panel can be obtained as follows (DOE, 1996):

$$Q_p = Q_{gr} + Q_c (Equation A-2)$$

where

 Q_{gr} = Volumetric flow rate due to gas generation

 Q_c = Volumetric flow rate due to panel volumetric closure

The volumetric flow rate due to gas generation is calculated as the gas generation rate (0.1 moles per drum per year) times the number of drums within a panel times the specific volume under atmospheric pressure. The VOCs concentrations at the E-300 drift must be restricted to the limits found in Table IV.F.2.c of the HWFP, which are shown in Table A-3.

Table A-1 Schedule for Panel Closure (After Westinghouse, 2002)

Panel #	Closure time (years)
1	5.11
2	6.15
3	7.36
4	9.39
5	11.93
6	14.55
7	17.38
8	23.18
9	28.98
10	35.00

Table A-2 Maximum Headspace Concentrations for VOCs (After DOE, 1996, and WIPP Waste Information System Headspace Gas Concentration Report, 2002)

Compound	Maximum Headspace Concentration (milligrams per cubic meter)
Carbon Tetrachloride	3625.77
Chlorobenzene	63.99
Chloroform	76.79
1,1-Dichloroethene	48.68
Methylene Chloride	3387.03
1,1,2,2-Tetrachloroethane	69.65
Toluene	105.51
1,2-Dichloroethane	1.24
1,1,1-Trichloroethane	145.75

Table A-3 VOC Concentrations of Concern

(After Table IV.F.2.c of the HWFP. This list of VOCs is the same as the list of VOCs in the previous design (DOE, 1996a) except for 1,2-dichloroethane and 1,1,1-trichloroethane.)

	Drift E-300 Concentration
Compound	Limit (micrograms per cubic
	meter)
Carbon Tetrachloride	1050
Chlorobenzene	1015
Chloroform	890
1,1-Dichloroethene	410
Methylene Chloride	6700
1,1,2,2-Tetrachloroethane	350
Toluene	715
1,2-Dichloroethane	175
1,1,1-Trichloroethane	3200

A.3.0 Model for Restricted Flow of VOCs

The assumptions for the restricted air-flow model are as follows:

- Gases (including VOCs) within the void space will obey the Ideal Gas Law. The gases
 will be generated at a rate of 0.1 moles per drum per year and will be stored by an increase
 in gas pressure. The rate of pressure buildup will be so gradual that it occurs at constant
 temperature.
- Volumetric reduction due to creep will reduce the void space at a rate of 31,430 ft³ (890 m³) per year (Appendix B) and will result in pressurization.
- Flow of gas out of the panel will obey Darcy's Law under quasi steady-state conditions.
 Under quasi steady-state conditions, the air pressure within the panel closure system will change so gradually that the compressive storage of the air within the void space of the panel closure system could be neglected.
- Rates of gas generation, air outflow, and change in compressive storage will balance.
- Hydrodynamic dispersion through the barrier will be neglected.
- Analysis will consider the superposition of flow rates from individual panels according to the operating schedule for a nominal operational life of 35 years.

After panel closure, the volume, moles of gas, and pressure change as functions of time. The Ideal Gas Law (Hiller and Herber, 1960) is written as:

$$p = \frac{n \cdot R \cdot T}{V}$$
 (Equation A-3)

where

p =Pressure in the panel

n =Moles of gas in the panel

R =Universal gas constant

T =Absolute temperature

V =Volume of the panel void space

Differentiating Equation A-3 with respect to time t and using the chain rule results in:

$$\frac{dp}{dt} = R \cdot T \cdot \frac{\frac{dn}{dt} \cdot V - n \cdot \frac{dV}{dt}}{V^2}$$
 (Equation A-4)

The rate at which gas enters the panel minus the rate that gas leaves the panel must equal the change in moles stored. Therefore, the mass-balance relationship can be written as follows (DOE, 1996):

$$\frac{dn}{dt} = g_r - \frac{p}{R \cdot T} \cdot K_s \cdot \frac{A}{L} \cdot \frac{p - p_{atm}}{g}$$
 (Equation A-5)

where

 g_r = Panel gas generation rate

 p_{atm} = Atmospheric pressure

g = Air density

 K_s = Effective panel closure system conductivity

A =Cross-sectional area

L = Length of flow path

Conductance (C) can be defined as follows:

$$C = K_s \cdot \frac{A}{L}$$
 (Equation A-6)

Substituting into the ordinary differential equations, the following relations can be obtained:

$$\frac{dp}{dt} = R \cdot T \cdot \frac{\left(g_r - \frac{p}{R \cdot T} \cdot C \cdot \frac{p - p_{atm}}{g}\right) \cdot V - n \cdot \frac{dV}{dt}}{V^2}$$
 (Equation A-7)

$$\frac{dn}{dt} = g_r - \frac{p}{R \cdot T} \cdot C \cdot \frac{p - p_{atm}}{g}$$
 (Equation A-8)

These two first-order coupled ordinary differential equations can be solved by a simple explicit finite difference technique as follows:

$$p_{j} = p_{j-1} + R \cdot T \cdot \frac{(g_{r} - \frac{p_{j-1}}{R \cdot T} \cdot C \cdot \frac{p_{j-1} - p_{atm}}{g}) \cdot V - n_{j-1} \cdot \frac{dV}{dt}}{V^{2}} \cdot \Delta t \qquad \text{(Equation A-9)}$$

$$n_{j} = n_{j-1} + (g_{r} - \frac{p_{j-1}}{R \cdot T} \cdot C \cdot \frac{p_{j-1} - p_{atm}}{\mathbf{g}}) \cdot \Delta t$$
 (Equation A-10)

where

 p_j , n_j = the pressure and moles of gas at the current time step

 p_{i-1} , n_{i-1} = the pressure and moles of gas at the previous time step

The initial conditions for the ordinary differential equations include: (1) the initial pressure equals atmospheric pressure; and (2) the initial moles of gas can be determined by the Ideal Gas Law at initial volume and pressure. Further note that the volume can be approximated as a linear function of time:

$$V(t) = \mathbf{a} \cdot t + \mathbf{b}$$
 (Equation A-11)

where

a = Slope of the volume-time relationship

b = Intercept of volume-time relationship

t = Time

These expressions can be substituted into the above explicit finite difference relationships, and the pressure and molar air-flow rates can be determined as functions of time.

A4.0 Effective Intrinsic Permeability of a Parallel System

The effective flow conductance for a parallel system consisting of n flow components can be obtained in terms of the conductances of its flow components as follows (Freeze and Cherry, 1979):

$$C_t = \sum_{i=1}^{n} C_i$$
 (Equation A-12)

where

 C_t = Total flow conductance of the system

 C_i = Flow conductance of the i^{th} component

Based on the definition of flow conductance (Equation A-6), Equation A-12 can be rewritten as:

$$K_t \frac{A_t}{L} = \sum_{i=1}^{n} K_i \frac{A_i}{L}$$
 (Equation A-13)

or

$$K_t = \frac{\sum_{i=1}^{n} K_i A_i}{A_t}$$
 (Equation A-14)

where

 K_t = Effective conductivity of the system

 A_i = Cross-sectional area of the i^{th} component

 A_t = Total cross-sectional area of the system $(\sum_{i=1}^n A_i)$

L = Length of flow path

A5.0 Effective Intrinsic Permeability of a Series System

The effective flow conductance for a series system consisting of n flow components can be obtained in terms of the conductances of its flow components as follows (Freeze and Cherry, 1979):

$$\frac{1}{C_t} = \sum_{i=1}^n \frac{1}{C_i}$$
 (Equation A-15)

where

 C_t = Total flow conductance of the system

 C_i = Flow conductance of the i^{th} component

Based on the definition of flow conductance (Equation A-6), Equation A-15 can be rewritten as follows:

$$\frac{L_t}{K_t A} = \sum_{i=1}^n \frac{L_i}{K_i A}$$
 (Equation A-16)

or

$$K_t = \frac{L_t}{\sum_{i=1}^n \frac{L_i}{K_i}}$$
 (Equation A-17)

where

 K_t = Effective conductivity of the system

 L_i = Length of flow path for i^{th} component

 L_t = Total length of flow path $(\sum_{i=1}^n L_i)$

A =Cross-sectional area of the flow path

A6.0 References

Freeze, A., and J. Cherry, 1979, *Groundwater*, Prentice Hall, Inc., Englewood Cliffs, New Jersey.

Hiller, L., and R. Herber, 1960, *Principles of Chemistry*, McGraw-Hill Book Company, New York.

U.S. Department of Energy (DOE), 1996, "Detailed Design Report for an Operational Phase Panel Closure System," *DOE/WIPP 96-2150*, U.S. Department of Energy, WIPP Project Office, Carlsbad, New Mexico.

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Westinghouse TRU Solutions, 2002, "Mining/Emplacement Schedule," June 1st 2002 update.

WIPP Hazardous Waste Facility Permit, NM 4890139088-TSDF, Aug. 31, 2001, Module IV - Geologic Repository Disposal.

WIPP Waste Information System, 2002, "Headspace Gas Concentration Report", Report RP0430, 4/25/2002.

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APPENDIX B CALCULATIONS OF PANEL VOLUME CLOSURE

APPENDIX B CALCULATIONS OF PANEL VOLUME CLOSURE

B.1.0 Introduction

This appendix presents the closure mechanisms and supporting calculations for panel volumetric closure for the analysis of gas pressurization within a closed panel at the WIPP. The volume reduction is due to the panel volume change from viscoplastic creep closure of the walls, roof, and floor. As the walls, roof, and floor of the excavations converge, the total volume of the panel decreases. The volumetric closure of a panel is the result of several different mechanisms working simultaneously. These mechanisms include:

- Viscoplastic creep of the salt toward the excavation
- Fracturing in the roof and floor caused by the deviatoric stresses around the excavation
- Bed separation at the clay seams in the roof and the floor.

The combination of these three mechanisms causes the observed convergence rates in Panels 1 and 2. Of these mechanisms, only creep of the salt reduces the total volume of the panel and pore space in the surrounding disturbed rock zone (DRZ). Fracturing in the roof and floor and bed separation transfer the void volume within the excavation to the DRZ. This void volume within the DRZ is assumed to be interconnected with the open excavation. Therefore the total reduction in volume within the panel, based simply on room closure, overestimates the effective reduction in void volume. However, quantifying the amount of interconnected void space within the DRZ would require a much more detailed analysis. Using the total volume change calculated from the room closure measurements is therefore considered conservative.

Other assumptions made in this calculation are:

- The volumetric closure rates are constant after panel closure.
- The waste in the panel provides no significant resistance to creep closure during the initial 35 years.
- The air volume is the total volume of the excavations minus the solid volume of the waste in drums or other waste packages. The solid volume is estimated to be 3,908 m³ (138,000 ft³) (DOE, 1996).

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- The closure rate of each room in the panels equals the closure rate at the mid-width and mid-height of the room.
- The length of each room or drift is constant. To simplify the calculations, only the width and height change with creep closure.

B.2.0 Panel Volume Change Calculation

The panel volume change calculation is performed in steps. First, the initial panel volume is calculated, then the room and drift closure rates are calculated, and finally the panel volumetric closure rate is determined. Because the closure rates and the closure history in Panel 2 are different than Panel 1, the volume calculations for each panel are done separately. Following is a detailed description of each part of the calculation for Panel 1 and then for Panel 2.

B.2.1 Panel 1 Volume Change Calculation

B.2.1.1 Initial Panel Volume

The initial panel volume is determined immediately after completion of excavation. The total volume is calculated by summing the individual room and drift volumes within the panel. These volumes are based on the as-built dimensions of the excavated rooms and drifts in Panel 1 (DOE, 1993). Table B-1 presents the room and drift dimensions and the calculated volume of each room and drift. The total initial volume of Panel 1 is 47,757 m³ (1,686,500 ft³).

The total solid volume of the waste in a filled panel is 3,908 m³ (138,000 ft³) (DOE, 1996). Subtracting the waste volume from the total panel volume gives the total initial void volume (43,850 m³ [1,548,500 ft³]) in the panel.

B.2.1.2 Closure Rates

Using convergence data from Panel 1 the average closure rates of the rooms and drifts are determined. Closure rates within the rooms and drifts are higher in the first five years after excavation. When Panel 2 mining began, closure rates in Panel 1 increased about 30% on average. Therefore, three distinct time periods are considered: 0 to 5 years, 6 to 13 years, and beyond 13 years. The roof-to-floor and wall-to-wall closure rates for each of the rooms and drifts are presented in Table B-2.

Because data from the east end of S1600 are not available for the Panel 2 mining period, the rates beyond five years for this area are assumed to be the same as in the west end of S1600 in the panel.

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Table B-1 Initial Room and Drift Dimensions and Volume of Panel 1

Room or Drift	Initial Width (m)	Initial Height (m)	Initial Length (m)	Initial Volume (m³)
Room 1	10.06	3.96	91.44	3644
Room 2	10.06	3.96	91.44	3644
Room 3	10.06	3.96	91.44	3644
Room 4	10.06	3.96	91.44	3644
Room 5	10.06	3.96	91.44	3644
Room 6	10.06	3.96	91.44	3644
Room 7	10.06	4.27	91.44	3925
S1950: Room 1 to Room 7	10.06	4.27	258.5	11094
S1950: Access to Room 1	6.10	3.96	12.18	294
S1600: Room 1 to Room 5	10.06	3.96	174.7	6961
S1600: Room 5 to Room 7	10.06	4.27	79.86	3428
S1600: Access to Room 1	4.27	3.66	12.18	190
Total Initial Panel Volume				47757

Table B-2 Panel 1 Room and Drift Closure Rates

	Vertical Closure Rates			Horizontal Closure Rates		
Room or Drift	0 to 5	6 to 13	> 13	0 to 5	6 to 13	> 13
	Years	Years	Years	Years	Years	Years
	(cm/yr)	(cm/yr)	(cm/yr)	(cm/yr)	(cm/yr)	(cm/yr)
Room 1	9.736	6.234	7.130	6.81	3.138	4.006
Room 2	9.736	6.303	6.057	6.81	3.688	4.446
Room 3	9.736	5.493	6.743	6.81	4.067	5.665
Room 4	9.736	5.441	6.496	6.81	3.831	4.496
Room 5	9.736	5.345	6.495	6.81	3.836	4.879
Room 6	9.736	5.305	6.933	6.81	2.913	3.976
Room 7	9.736	5.687	6.642	6.81	3.579	4.578
S1950: Room 1 to Room 7	9.736	5.513	11.594	6.81	3.370	5.612
S1950: Access to Room 1	5.878	4.436	6.490	5.09	2.674	4.079
S1600: Room 5 to Room 7	9.736	5.064	6.054	6.81	3.212	3.935
S1600: Room 1 to Room 5	9.736	5.064	6.054	6.81	3.212	3.935
S1600: Access to Room 1	3.478	1.753	1.938	4.01	1.954	2.157

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B.2.1.3 Volumetric Panel Closure Rate

Using the closure rates from Table B-2, the dimensions of the rooms and drifts in Panel 1 can be calculated at the end of each progressive year or for subsequent years using the following equations:

$$D_t = D_0 - C_5$$
 at five years

$$D_t = D_0 - C_5 - (t - 5)C_{ssb}$$
 for years six to thirteen

$$D_t = D_0 - C_5 - 8C_{ssb} - (t - 13)C_{ssa}$$
 for years > thirteen

where:

t = Number of years since excavation

 D_t = Magnitude of the dimension (height or width) after year t

 D_0 = Original magnitude of the dimension

 C_5 = Total convergence in the direction of the dimension after the first five years

 C_{ssb} = Steady-state convergence rate of the dimension before Panel 2 mining

 C_{ssa} = Steady-state convergence rate of the dimension after Panel 2 mining

The dimension cannot go below zero. The length is assumed to remain constant. The volume is then calculated as:

$$V_t = H_t \cdot W_t \cdot L$$

where:

 V_t = Volume of a section after year t

 H_t = Height of a section after year t

 W_t = Width of a section after year t

L = Length of a section (constant)

The total volume for the panel is calculated by summing the volumes of the individual sections as follows:

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$$V_{Pt} = \sum_{i=1}^{n} (V_t)_i - V_w$$

where:

 V_{Pt} = Volume of the entire panel, less the volume of the waste, after year t

n = Number of sections

 V_{w} = Volume of the solids in the waste

The volume versus time for Panel 1 is shown graphically in Figure B-1 and in tabular form in Table B-3. The average annual volume loss was found to be 790 cubic meters (27900 ft³) per year.

B.2.2 Panel 2 Volume Change Calculation

The calculation of volume change for Panel 2 differs slightly from that of Panel 1, primarily because only about two years' data is available to date from Panel 2. Panel 2 was subdivided slightly differently than Panel 1 due to its different instrument layout.

B.2.2.1 Initial Panel 2 Volume

Table B-4 presents the room and drift initial dimensions and the calculated initial volume of each room and drift. The total initial volume of Panel 2 is 46,166 m³ (1,630,300 ft³). Subtracting the waste volume from the total panel volume gives the total initial void volume (42,258 m³ [1,492,300 ft³]) in the panel.

B.2.2.2 Panel 2 Closure Rates

Using convergence data from Panel 2, the average closure rates of the rooms and drifts are determined. Due to the relatively short time since excavation in Panel 2, two rate periods were used: 0 to 1 years and beyond 1 year. This assumes that the rate calculated for the second year after excavation is the long-term steady-state rate. Because it usually takes about two years to reach steady-state, the values used here are likely to overestimate the long-term rates. The roof-to-floor and wall-to-wall closure rates for each of the rooms and drifts are presented in Table B-5.

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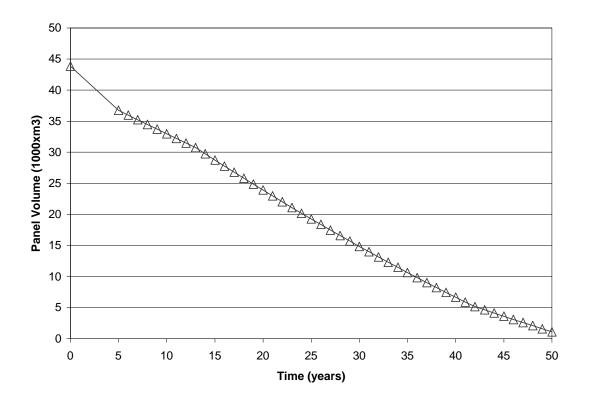


Figure B-1 Panel 1 Volume versus Time

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Table B-3 Panel 1 Volume

Year	Volume (m³)	Year (cont'd)	Volume (m³)
0	43849.77	28	16599.56
5	36744.52	29	15724.08
6	35980.50	30	14857.13
7	35220.91	31	13998.73
8	34465.74	32	13148.86
9	33715.00	33	12307.53
10	32968.69	34	11474.74
11	32226.81	35	10650.49
12	31489.35	36	9834.775
13	30756.33	37	9027.598
14	29752.78	38	8228.958
15	28757.76	39	7438.857
16	27771.29	40	6657.294
17	26793.35	41	5884.269
18	25823.95	42	5166.191
19	24863.09	43	4642.604
20	23910.77	44	4124.191
21	22966.99	45	3610.953
22	22031.74	46	3102.889
23	21105.03	47	2599.999
24	20186.86	48	2102.285
25	19277.23	49	1609.744
26	18376.13	50	1122.378
27	17483.58		

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Table B-4 Initial Room and Drift Dimensions and Volume of Panel 2

	Initial	Initial	Initial	Initial
Room or Drift	Width	Height	Length	Volume
	(m)	(m)	(m)	(m3)
Room 1	10.06	3.96	91.44	3643
Room 2	10.06	3.96	91.44	3643
Room 3	10.06	3.96	91.44	3643
Room 4	10.06	3.96	91.44	3643
Room 5	10.06	3.96	91.44	3643
Room 6	10.06	3.96	91.44	3643
Room 7	10.06	3.96	91.44	3643
S2180: Room 1 to west rib Room 2	10.06	3.96	40.54	1615
S2520: Room 1	10.06	3.96	10.06	401
S2180: Room 2 to mid Room 3/4 pillar	10.06	3.96	65.84	2623
S2520: East rib of Room 1 to mid Room 2/3 pillar	10.06	3.96	55.78	2222
S2520: Mid Room 2/3 pillar to mid Room 3/4 pillar	10.06	3.96	40.54	1615
S2180: Mid Room 3/4 pillar to east rib Room 4	10.06	3.96	25.30	1008
S2520: Mid Room 3/4 pillar mid Room 5/6 pillar	10.06	3.96	81.08	3230
S2180: East rib Room 4 to mid Room 5/6 pillar	10.06	3.96	55.78	2222
S2520: Mid Room 5/6 pillar to east rib Room 6	10.06	3.96	25.30	1008
S2180: Mid Room 5/6 pillar to Room 7	10.06	3.96	65.84	2623
S2520: East rib Room 6 to Room 7	10.06	3.96	40.54	1615
S2180: Access to west rib Room 1	4.27	3.66	12.18	190
S2520: Access to west rib Room 1	6.10	3.96	12.18	294
Total Initial Panel Volume				46,166

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Table B-5 Panel 2 Room and Drift Closure Rates

	Vert Closure		Horizontal Closure Rates	
Room or Drift	0 to 1 Years	> 1 Years	0 to 1 Years	> 1 Years
	(cm/yr)	(cm/yr)	(cm/yr)	(cm/yr)
Room 1	17.19	9.375	12.14	6.246
Room 2	10.14	9.375	14.85	6.113
Room 3	17.51	8.432	15.39	5.957
Room 4	20.19	8.923	16.74	6.341
Room 5	18.41	7.855	14.98	5.495
Room 6	12.21	7.672	14.08	5.488
Room 7	13.10	8.548	11.33	5.106
S2180: Room 1 to west rib Room 2	19.25	8.723	6.19	6.323
S2520: Room 1	11.66	7.633	15.78	5.562
S2180: Room 2 to mid-Room 3/4 pillar	21.37	9.473	6.19	6.323
S2520: East rib of Room 1 to mid Room 2/3 pillar	25.26	9.458	15.78	5.562
S2520: Mid Room 2/3 pillar to Mid Room 3/4 pillar	22.13	8.806	15.68	5.797
S2180: Mid Room 3/4 pillar to east rib Room 4	24.30	10.756	13.91	6.323
S2520: Mid Room 3/4 pillar mid Room 5/6 pillar	20.44	8.406	15.68	5.797
S2180: East rib Room 4 to mid Room 5/6 pillar	18.10	9.463	13.91	6.323
S2520: Mid Room 5/6 pillar to east rib Room 6	12.75	8.189	10.60	4.666
S2180: Mid Room 5/6 pillar to Room 7	12.08	7.065	12.20	4.832
S2520: East rib Room 6 to Room 7	11.36	6.624	10.60	4.666
S2180: Access to west rib Room 1	6.92	4.266	7.12	4.358
S2520: Access to west rib Room 1	7.39	5.102	11.06	5.804

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B.2.2.3 Volumetric Panel Closure Rate

Using the closure rates from Table B-4, the dimensions of the rooms and drifts in Panel 2 can be calculated at the end of each progressive year or for subsequent years using the following equations:

$$D_t = D_0 - C_1$$
 after the first year

$$D_t = D_0 - C_1 - C_2$$
 after the second year

$$D_t = D_0 - C_1 - C_2 - (t - 2)C_{ss}$$
 for years > two

where:

t = Number of years since excavation

 D_t = Magnitude of the dimension (height or width) after year t

 D_0 = Original magnitude of the dimension

 C_1 = Total convergence in the direction of the dimension after the first year

 C_2 = Total convergence in the direction of the dimension during the second year

 C_{ss} = Steady-state convergence rate of the dimension

The volume is then calculated as for Panel 1 (Section B.2.1.3). The volume versus time for Panel 2 is shown graphically in Figure B-2 and in tabular form in Table B-6. The average annual volume loss was found to be 989 m³ (34,930 ft³) per year.

B.2.3 Average Volumetric Panel Closure Rate

In the current analyses, the volume closure rate is taken as the average of the volume closure rates of Panels 1 and 2 that is 890 m^3 ($31,430 \text{ ft}^3$) per year. Also, the void volume of Panel 2 ($42,258 \text{ m}^3$) is taken as typical of all panels.

B.3.0 References

U.S. Department of Energy (DOE), 1996, "Detailed Design Report for an Operational Phase Panel Closure System," *DOE/WIPP 96-2150*, U.S. Department of Energy, WIPP Project Office, Carlsbad, New Mexico.

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U.S. Department of Energy (DOE), 1993, "Geotechnical Analysis Report, July 1991 through June 1992," *DOE-WIPP 93-019*, U.S. Department of Energy, Washington D.C.

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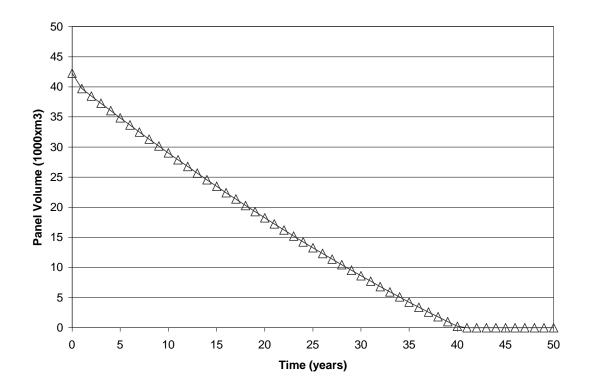


Figure B-2 Panel 2 Volume versus Time

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Table B-6 Panel 2 Volume

V	Volume	Year	Volume
Year	(m ³)	(cont'd)	(m ³)
0	42,258	21	17,232
1	39,706	22	16,229
2	38,487	23	15,237
3	37,264	24	14,257
4	36,053	25	13,289
5	34,853	26	12,332
6	33,665	27	11,387
7	32,489	28	10,453
8	31,324	29	9,531
9	30,170	30	8,620
10	29,029	31	7,721
11	27,898	32	6,834
12	26,780	33	5,958
13	25,672	34	5,094
14	24,577	35	4,241
15	23,493	36	3,409
16	22,420	37	2,600
17	21,360	38	1,803
18	20,310	39	1,016
19	19,272	40	241
20	18,246		

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APPENDIX C
FLAC MODELING OF THE WIPP PANEL CLOSURE SYSTEM

APPENDIX C FLAC MODELING OF THE WIPP PANEL CLOSURE SYSTEM

Numerical modeling is considered here for quantifying the interaction of block wall with the surrounding rocksalt. A series of models were developed to evaluate the interaction of the panel closure system with the surrounding salt. This appendix discusses the code used and describes the material constitutive models used in the stress analysis.

All calculations were performed in accordance with the RockSol Consulting Group, Inc., Quality Assurance Program and comply with Westinghouse TRU Solutions requirements. These constitute quality records and are maintained in accordance with WIPP procedures. These records include verification and validation documents.

C.1.0 FLAC Code

FLAC software has been used for numerical modeling of the underground excavations at the Waste Isolation Pilot Plant (WIPP) since 1991. FLAC (Itasca, 2000) is a finite difference code that simulates the behavior of rock and soil-like structures. The WIPP Reference Creep Law is built into FLAC. The version of FLAC (Version 4.00) used for the panel closure system modeling has been verified against the WIPP Second Benchmark Problem (Krieg, 1984).

C.2.0 Material Constitutive Models

The material properties associated with the material constitutive models are given in Tables C-1 through C-3. These are standard properties used in a wide variety of previous WIPP geotechnical FLAC modeling. The halite properties are based on Krieg (1984). The Mohr-Coulomb model was used for block wall and its properties were calculated using Atkinson et al. (1989) and Ahmed and Drysdale (1988) and ACI 530.1-95. The block wall has a minimum compressive strength of 5000 psi (34.5 MPa) (Appendix D).

C.3.0 References

Ahmed, H. and R. G. Drysdale, 1988, "Flexural Tensile Strength of Concrete Block Masonry," ASCE Journal of Structural Engineering, pp 50-66.

Atkinson, R. H., B. P. Amadei, S. Saeb, and S. Sture, 1989, "Response to Masonry Bed Joints in Direct Shear," ASCE Journal of Structural Engineering, pp 2276-2296.

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Itasca Consulting Group, Inc. (Itasca), 2000, "FLAC User's Guide," Itasca Consulting Group, Inc., Minneapolis, Minnesota.

Krieg, R. D., 1984, "Reference Stratigraphy and Rock Properties for the Waste Isolation Pilot Plant," SAND83-1908, Sandia National Laboratories, Albuquerque, New Mexico.

Table C-1 Halite Material Properties

Property	Value
Bulk modulus (GPa)	20.7
Shear modulus (GPa)	12.4
Density (km/m³)	2,300
Activation energy (cal/mol)	12,000
А	4.56
В	127
D (Pa ⁻ⁿ /s)	5.79x10 ⁻³⁶
n	4.9
Universal Gas constant (cal/(mol . K))	1.987
Critical strain rate (1/s)	5.39x10 ⁻⁰⁸

Table C-2 Concrete Material Properties

Property	Value
Bulk modulus (GPa)	11.6
Shear modulus (GPa)	9.0
Density (kg/m3)	2,300
Friction angle (degrees)	35
Cohesion (MPa)	9.1
Tension cut-off (MPa)	1.2

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Table C-3 Clay Seam, Rock/Concrete Contact, and Construction Joint Material Properties

Property	Value
Normal stiffness (Pa/m)	1.0x10 ¹²
Shear stiffness (Pa/m)	5.0x10 ¹⁰
Cohesion (Pa)	0.0
Friction (degrees)	30

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APPENDIX D TECHNICAL SPECIFICATIONS

SECTION 01010

SUMMARY OF WORK

PART 1 - GENERAL

1.1 Scope

This section includes:

- · Scope of Work
- Definitions and Abbreviations
- List of Drawings
- Work by Others
- Contractor's Use of Site
- Contractor's Use of Facilities
- Work Sequence
- Work Plan
- Health and Safety Plan (HASP)
- Contractor Quality Control Plan (CQCP)
- Submittals

1.2 Scope of Work

The Contractor shall furnish all labor, materials, equipment and tools to construct two (2) panel closure systems. The closure system consists of an explosion isolation wall and run of mine salt backfill, one of each to be installed in the air-intake drift and the air-exhaust drift of a waste disposal panel, as shown on the Drawings and described in these Specifications. Unless otherwise agreed by Westinghouse, the Contractor shall use Westinghouse supplied equipment underground. Such use shall be coordinated with Westinghouse and may include the use of Westinghouse qualified operators.

The scope of work shall include but not necessarily be limited to the following units of work:

- Develop work plan, health and safety plan (HASP) and contractors quality control plan (CQCP)
- Prepare and submit all plans requiring approval
- Mobilize to site
- Coordinate construction with WIPP operations

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- Perform the following for the air-intake entry and the air-exhaust entry:
 - Prepare the surfaces for the explosion isolation wall
 - Construct the explosion isolation wall
 - Place run of mine salt material
- Clean up construction areas in underground and above ground
- Submit all required record documents
- Demobilize from site

1.3 Definitions and Abbreviations

Definitions

<u>Concrete masonry units</u>—Concrete blocks used for construction of the explosion isolation wall.

<u>Creep</u>—Viscoplastic deformation of salt under deviatoric stress.

<u>Explosion isolation wall</u>—A mortared concrete block wall adjacent to the panel waste disposal area that can sustain the pressure and temperature transients of a methane explosion.

Methane explosion—A postulated deflagration caused by methane gas at an explosive level.

<u>Partial closure</u>—The process of rendering a part of the hazardous waste management unit in the underground repository inactive and closed according to approved facility closure plans.

<u>Volatile Organic Compound</u> (VOC) —Any VOC with Hazardous Waste Facility Permit emission limits.

Westinghouse—Westinghouse TRU Solutions, LLC as the construction management authority.

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Abbreviations/Acronyms

ACI American Concrete Institute

ANSI American National Standards Institute

ASTM American Society for Testing and Materials

CFR Code of Federal Regulations

CQCP Contractor Quality Control Plan

DOE U.S. Department of Energy

DWG Drawing

EPA U.S. Environmental Protection Agency

HASP Health And Safety Plan

JHA Job Hazard Analysis

LHD Load Haul Dump

LLC Limited Liability Corporation

MSHA U.S. Mine Safety and Health Administration

RCRA Resource Conservation and Recovery Act

USACE U.S. Army Corps of Engineers

VOC Volatile Organic Compound

WIPP Waste Isolation Pilot Plant

1.4 List of Drawings

The following Drawings are made apart of this Specification:

DWG 110-CD001 Panel closure system, title sheet

DWG 110-CD002 Panel closure system, underground waste disposal panel configuration

DWG 110-CD003 Panel closure system, construction details

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1.5 Work by Others

Survey

All survey work to locate, control, confirm, and complete the work will be performed by Westinghouse. All survey work for record purposes will be performed by Westinghouse. The Contractor shall be responsible for developing the concrete block wall to fit the excavation.

Other

Westinghouse may elect to perform certain portions, or all, of the work. The work performed by the Westinghouse will be defined prior to the contract. Unless otherwise agreed by Westinghouse, the Contractor shall use underground equipment furnished by Westinghouse for construction of the explosion isolation walls and placement of the run of mine salt. Underground mining personnel who are qualified for the operation of such underground construction equipment may be made available to the Contractor. The use of Westinghouse equipment shall be coordinated with Westinghouse.

1.6 Contractor's Use of Site

Site Conditions

The site is located near Carlsbad, New Mexico, as shown on the Drawings. The underground arrangements and location of the WIPP waste disposal panels are shown on the Drawings. The work is to construct the explosion isolation walls and place run of mine salt in the air-intake and air-exhaust drifts of one of the panels upon completion of the disposal phase of that panel. The waste disposal panels are located approximately 2,150 ft (655 m) below the ground surface. The Contractor shall visit the site and become familiar with the site and site conditions prior to preparing his bid proposal.

Contractor's Use of Site

Areas at the ground surface will be designated for the Contractor's use in assembling and storing his equipment and materials. The Contractor shall utilize only those areas designated.

Limited space within the underground area will be designated for the Contractor's use for storage of material and setup of equipment.

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Coordination of Contractor's Work

The Contractor is advised that on-going waste emplacement and excavation operations will be conducted throughout the period of construction of the panel closure system. These operations have priority over the Contractor's work. The Contractor shall coordinate his construction operations with that of the waste emplacement and mining operations. All coordination shall be through Westinghouse.

1.7 Contractor's Use of Facilities

Existing facilities at the site available for use by the Contractor are:

- Waste shaft conveyance
- Salt skip hoist
- 460 volt AC, 3 phase power
- Water (underground, at waste shaft only) (above ground, at location designated by Westinghouse)

Additional information on these facilities is presented in Section 02010.

1.8 Work Sequence

Work Sequence shall be as shown on the Drawings and as directed by Westinghouse.

1.9 Work Plan

The Contractor shall prepare a Work Plan fully describing his proposed construction operation. The work plan shall define all proposed equipment and methods. Westinghouse shall approve the Work Plan and no work shall be performed prior to approval of the Work Plan.

1.10 Health and Safety Plan (HASP)

The Contractor shall obtain, review, and agree to applicable portions of the existing WIPP Safety Manual, WP 12-1. The Contractor shall prepare a project-specific HASP taking into account all applicable sections of the WIPP Safety Manual. All personnel shall be qualified to work underground. All personnel operating heavy construction equipment shall be qualified to operate such equipment. The Contractor shall also perform a Job Hazard Analysis (JHA) in accordance with WP 12-111. Westinghouse shall approve the HASP and JHA and no work shall be performed prior to approval of the HASP and JHA.

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1.11 Contractor Quality Control Plan (CQCP)

The Contractor shall prepare a CQCP identifying all personnel and procedures necessary to produce an end product, which complies with the contract requirements. The CQCP shall comply with all Westinghouse requirements, including operator training and qualification; and Section 01400, Contractor Quality Control, of this Specification. Westinghouse shall approve the CQCP and no work shall be performed prior to approval of the CQCP.

1.12 Submittals

Submittals shall be in accordance with Westinghouse Submittal Procedures and as required by the individual Specifications.

PART 2 - PRODUCTS

Not used

PART 3 - EXECUTION

Not used

End of section

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SECTION 01090

REFERENCE STANDARDS

PART 1 - GENERAL

1.1 Scope

This section includes:

- Provision of Reference Standards at Site
- Acronyms used in Contract Documents for Reference Standards

1.2 Quality Assurance

For products or workmanship specified by association, trade, or Federal Standards, the Contractor shall comply with requirements of the standard, except when more rigid requirements are specified or are required by applicable codes.

Conform to reference by date of issue current on the date of the owner-contractor agreement.

The Contractor shall obtain, at his own expense, a copy of the standards referenced in the individual Specification sections and shall maintain that copy at the jobsite until completion and acceptance of the work.

Should specified Reference Standards conflict with the contract documents, the Contractor shall request clarification from Westinghouse before proceeding.

1.3 Schedule of References

Various publications referenced in other sections of the Specifications establish requirements for the work. These references are identified by document number and title. The addresses of the organizations responsible for these publications are listed below.

ACI ACI International

P.O. Box 9094

Farmington Hills, MI 48333

Ph: 248-848-3700

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ANSI American National Standards Institute

25 West 43rd St.

New York NY 10036 Ph: 212-642-4900

Fax: 212-398-0023

ASTM ASTM International

100 Barr Harbor Drive

P.O. Box C700, West Conshohocken,

Pennsylvania, USA 19428-2959

Ph: 610-832-9585 Fax: 610-832-9555

CFR Code of Federal Regulations

Government Printing Office

P.O. Box 371954, Pittsburgh, PA 15250-7954

Ph: 202-512-1800 Fax: 202-512-2250

EPA Environmental Protection Agency

Public Information Center

401 M St., SW

Washington, DC 20460

Ph: 202-260-2080 Fax: 202-260-6257

FTM-STD Federal Test Method Standards

Standardization Documents Order Desk

Bldg. 4D

700 Robbins Ave.

Philadelphia, PA 19111-5094

Ph: 215-697-2179 Fax: 215-697-2978

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NIST National Institute of Standards and Technology

100 Bureau Drive, Stop 3460 Gaithersburg, MD 20899-3460

Ph: 301-975-6478 Fax: 301-975-8295

NRMCA National Ready-Mixed Concrete Association

900 Spring St

Silver Spring, MD 20910

Ph: 301-587-1400 Fax: 301-585-4219

NTIS National Technical Information Service

U.S. Department of Commerce

Springfield, VA 22161

Ph: 703-605-6000 Fax: 703-321-8547

PCA Portland Cement Association

5420 Old Orchard Road

Skokie, IL 60077 Ph: 847-966-6200

Fax: 847-966-8389

End of section

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SECTION 01400

CONTRACTOR QUALITY CONTROL

PART 1 - GENERAL

1.1 Scope

This section includes:

- Contractor Quality Control Plan (CQCP)
- Reference Standards
- Quality Assurance
- Tolerances
- Testing Services
- Inspection Services
- Submittals

1.2 Related Sections

- 01090 Reference Standards
- 01600 Material and Equipment
- 02222 Excavation
- 03100 Mortar
- 03300 Unit Masonry System
- 03400 Masonry Explosion Isolation Structure
- 04100 Salt Backfill

1.3 Contractor Quality Control Plan (CQCP)

The Contractor shall prepare a Contractor Quality Control Plan (CQCP), as described in Part 3. No work shall be performed prior to Westinghouse approval of the CQCP.

1.4 Reference Standards

Refer to individual Specification sections for standards referenced therein, and to Section 01090, Reference Standards, for general listing.

Standards referenced in this section are as follows:

ASTM C 1077-02 Standard Practice for Laboratories Testing Concrete and Concrete
Aggregates for Use in Construction and Criteria for Laboratory Evaluation

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ASTM C 1093-95	Standard Practice for Accreditation of Testing Agencies for Unit Masonry
ASTM E 329-01a	Standard Specification for Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction
ASTM E 543-02	Standard Practice for Agencies Performing Nondestructive Testing
ASTM E 548-94	Standard Guide for General Criteria Used for Evaluating Laboratory
	Competence

1.5 Quality Assurance

The Contractor shall:

- Monitor suppliers, manufacturers, products, services, site conditions, and workmanship to produce work of specified quality
- Comply with specified standards as minimum quality for the work except where more stringent tolerances, codes, or specified requirements indicate higher standards or more precise workmanship
- Perform work with qualified persons to produce required and specified quality

1.6 Tolerances

The Contractor shall:

 Monitor excavation, fabrication, and tolerances in order to produce acceptable work. The Contractor shall not permit tolerances to accumulate.

1.7 Testing Services

Unless otherwise agreed by Westinghouse, the Contractor shall employ an independent firm qualified to perform the testing services and other services specified in the individual Specification sections, and as may otherwise be required by Westinghouse. Testing and source quality control may occur on or off the project site.

The testing laboratory shall comply with applicable sections of the Reference Standards and shall be authorized to operate in the State of New Mexico.

Testing equipment shall be calibrated at reasonable intervals traceable to either the National Institute of Standards and Technology or accepted values of natural physical constants.

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1.8 Inspection Services

The Contractor may employ an independent firm to perform inspection services as a supplement to the Contractor's quality control as specified in the individual Specification sections, and as may be required by Westinghouse. Inspection may occur on or off the project site.

The inspection firm shall comply with applicable sections of the Reference Standards.

1.9 Submittals

The Contractor shall submit a CQCP as described herein.

Prior to start of work, the Contractor shall submit for approval, the testing laboratory name, address, telephone number and name of responsible officer of the firm as well as a copy of the testing laboratory compliance with the reference ASTM standards and a copy of report of laboratory facilities inspection made by Materials Reference Laboratory of National Institute of Standards and Technology with memorandum of remedies of any deficiencies reported by the inspection.

The Contractor shall submit the names and qualifications of personnel proposed to perform the required inspections, along with their individual qualifications and certifications. Once approved by Westinghouse these personnel shall be available as may be required to promptly and efficiently complete the work.

PART 2 - PRODUCTS

Not used

PART 3 - EXECUTION

3.1 General

The Contractor is responsible for quality control and shall establish and maintain an effective quality control system. The quality control system shall consist of plans, procedures, and organization necessary to produce an end product which complies with the contract requirements. The system shall cover all construction operations, both on site and off site, and shall be keyed to the proposed construction sequence. The project superintendent will be held responsible for the quality of work on the job. The project superintendent in this context is the individual with the responsibility for the overall management of the project including quality and production.

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3.2 Contractor Quality Control Plan

3.2.1 General

The Contractor shall supply, not later than 30 days after receipt of notice to proceed, the Contractor Quality Control Plan (CQCP) which implements the requirements of the Contract. The CQCP shall identify personnel, procedures, control, instructions, tests, records, and forms to be used. Construction shall not begin until the CQCP is approved by Westinghouse.

3.2.2 Content of the CQCP

The CQCP shall cover all construction operations, both on site and off site, including work by subcontractors, fabricators, suppliers, and purchasing agents and shall include, as a minimum, the following items:

- A description of the quality control organization, including a chart showing lines of authority and acknowledgment that the Contractor Quality Control (CQC) staff shall implement the control system for all aspects of the work specified.
- The name, qualifications (in resume format), duties, responsibilities, and authorities of each person assigned a CQC function.
- A description of CQCP responsibilities and a delegation of authority to adequately perform the functions described in the CQCP, including authority to stop work.
- Procedures for scheduling, reviewing, certifying, and managing submittals, including those of subcontractors, off site fabricators, suppliers, and purchasing agents. These procedures shall be in accordance with Westinghouse Submittal Procedures.
- Control, verification, and acceptance testing procedures as may be necessary to ensure that the work is completed to the requirements of the Drawings and Specifications.
- Procedures for tracking deficiencies from identification, through acceptable corrective action, to verification that identified deficiencies have been corrected.
- Reporting procedures, including proposed reporting formulas.

3.2.3 Acceptance of Plan

Acceptance of the Contractor's plan is conditional. Westinghouse reserves the right to require the Contractor to make changes in his CQCP and operations, including removal of personnel, if necessary, to obtain the quality specified.

3.2.4 Notification of Changes

After acceptance of the CQCP, the Contractor shall notify Westinghouse in writing of any proposed change. Proposed changes are subject to acceptance by Westinghouse.

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3.3. Tests

3.3.1 Testing Procedure

The Contractor shall perform specified or required tests to verify that control measures are adequate to complete the work to contract requirements. Upon request, the Contractor shall furnish, at his own expense, duplicate samples of test specimens for testing by Westinghouse. The Contractor shall perform, as necessary, the following activities and permanently record the results:

- Verify that testing procedures comply with contract requirements.
- Verify that facilities and testing equipment are available and comply with testing standards.
- Check test instrument calibration data against certified standards.
- Verify that recording forms and test identification control number system, including all of the test documentation requirements, have been prepared.
- Record the results of all tests taken, both passing and failing. Specification paragraph
 reference, location where tests were taken, and the sequential control number identifying
 the test will be given. If approved by Westinghouse, actual test reports may be submitted
 later with a reference to the test number and date taken. An information copy of tests
 performed by an off site or commercial test facility will be provided directly to
 Westinghouse.

3.4 Testing Laboratory

The testing laboratory shall provide qualified personnel to perform specified sampling and testing of products in accordance with specified standards, and the requirements of Contract Documents.

Reports indicating results of tests, and compliance or noncompliance with the contract documents will be submitted in accordance with Westinghouse submittal procedures. Testing by an independent firm does not relieve the Contractor of the responsibility to perform the work to the contract requirements.

3.5 Inspection Services

The inspection firm shall provide qualified personnel to perform specified inspection of products in accordance with specified standards.

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Reports indicating results of the inspection and compliance or noncompliance with the contract documents will be submitted in accordance with Westinghouse submittal procedures.

Inspection by the independent firm does not relieve the Contractor of the responsibility to perform the work to the contract requirements.

3.6 Completion Inspection

3.6.1 Pre-Final Inspection

At appropriate times and at the completion of all work, the Contractor shall conduct an inspection of the work and develop a punch list of items which do not conform to the Drawings and Specifications. The Contractor shall then notify Westinghouse that the work is ready for inspection. Westinghouse will perform this inspection to verify that the work is satisfactory and appropriately complete. A final punch list will be developed as a result of this inspection. The Contractor shall ensure that all items on this list are corrected and notify Westinghouse so that a final inspection can be scheduled. Any items noted on the final inspection shall be corrected in a timely manner. These inspections and any deficiency corrections required by this paragraph will be accomplished within the time slated for completion of the entire work.

3.6.2 Final Acceptance Inspection

The final acceptance inspection will be formally scheduled by Westinghouse based upon notice from the Contractor. This notice will be given to Westinghouse at least 14 days prior to the final acceptance inspection. The Contractor shall assure that all specific items previously identified as unacceptable, along with all remaining work performed under the contract, will be complete and acceptable by the date scheduled for the final acceptance inspection.

3.7 Documentation

The Contractor shall maintain current records providing factual evidence that required quality control activities and/or tests have been performed. These records shall include the work of subcontractors and suppliers and shall be on an acceptable form approved by Westinghouse.

3.8 Notification of Noncompliance

Westinghouse will notify the Contractor of any noncompliance with the foregoing requirements. The Contractor shall take immediate corrective action after receipt of such notice. Such notice, when delivered to the Contractor at the worksite, shall be deemed sufficient for the purpose of notification. If the Contractor fails or refuses to comply promptly, Westinghouse may issue an order stopping all or part of the work until satisfactory corrective action has been taken. No part

of the time lost due to such stop orders shall be made the subject of claim for extension of time or for excess costs or damages by the Contractor.

End of section

SECTION 01600

MATERIAL AND EQUIPMENT

PART 1 - GENERAL

1.1 Scope

This section includes:

- Equipment
- Products
- Transportation and Handling
- Storage and Protection
- Substitutions

1.2 Related Sections

- 01010 Summary of Work
- 01400 Contractor Quality Control
- 02010 Mobilization and Demobilization
- 02222 Excavation
- 03100 Mortar
- 03300 Unit Masonry System
- 03400 Masonry Explosion Isolation Structure
- 04100 Salt Backfill

1.3 Equipment

The Contractor shall specify his proposed equipment in the Work Plan. Power equipment for use underground shall be either electrical or diesel engine driven. All diesel engine equipment shall be certified for use underground at the WIPP site.

1.4 Products

The Contractor shall specify in the Work Plan, or in subsequently required submittals, the proposed products including, but not limited to, the mortar mix and its components, masonry blocks, and run of mine salt. The proposed products shall be supported by laboratory test results as required by the Specifications. All products shall be subject to approval by Westinghouse.

1.5 Transportation and Handling

The Contractor shall:

- Transport and handle products in accordance with manufacturer's instructions.
- Promptly inspect shipments to ensure that products comply with requirements, quantities are correct, and products are undamaged.
- Provide equipment and personnel to handle products by methods to prevent soiling, disfigurement, or damage.

1.6 Storage and Protection

The Contractor shall:

- Store and protect products in accordance with manufacturers' instructions.
- Store with seals and labels intact and legible.
- Store sensitive products in weather tight, climate controlled, enclosures in an environment favorable to product.
- Provide ventilation to prevent condensation and degradation of products.
- Store loose granular materials on solid flat surfaces in a well-drained area and prevent mixing with foreign matter.
- Provide equipment and personnel to store products by methods to prevent soiling, disfigurement, or damage.
- Arrange storage of products to permit access for inspection and periodically inspect to verify products are undamaged and are maintained in acceptable condition.

1.7 Substitutions

1.7.1 Equipment Substitutions

The Contractor may substitute equipment for that proposed in the Work Plan subject to Westinghouse approval.

1.7.2 Product Substitutions

The Contractor may not substitute products after the proposed products have been approved by Westinghouse unless he can demonstrate that the supplier/source of that product no longer exists in which case he shall submit alternate products with lab test results to Westinghouse for approval. In the case that product is a component in a mix, the Contractor shall perform mix testing using that component and submit laboratory test results.

PART 2 – PRODUCTS

Not used

PART 3 - EXECUTION

Not used

End of section

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SECTION 02010

MOBILIZATION AND DEMOBILIZATION PART 1 - GENERAL

1.1 Scope

This section includes:

- Mobilization of Equipment and Facilities to Site
- Contractor Use of Site
- Use of Existing Facilities
- Demobilization of Equipment and Facilities
- Site Cleanup

1.2 Related Sections

- 01010 Summary of Work
- 01600 Material and Equipment

PART 2 - PRODUCTS

Not used

PART 3 - EXECUTION

3.1 Mobilization of Equipment and Facilities to Site

Upon authorization to proceed, the Contractor shall mobilize his equipment and facilities to the jobsite. Equipment and facilities shall be as specified and as defined in the Contractor's Work Plan.

Westinghouse will provide utilities at designated locations. The Contractor shall be responsible for all hookups and tie-ins required for his operations.

The Contractor shall be responsible for providing his own office, storage, and sanitary facilities.

Areas will be designated for the Contractor's use in the underground area in the vicinity of the panel closure system installation. These areas are limited.

3.2 Contractor Use of Site

The Contractor shall use only those areas specifically designated for his use by Westinghouse. The Contractor shall limit his on-site travel to the specific routes required for performance of his work, and designated by Westinghouse.

3.3 Use of Existing Facilities

Existing facilities available for use by the Contractor are:

- Waste shaft conveyance
- Salt skip hoist
- 460 Volt AC, 3 phase power
- Water underground at waste shaft only
- · Water on surface at location designated by Westinghouse

The Contractor shall arrange for use of the facilities with Westinghouse and coordinate his actions and requirements with ongoing Westinghouse operations.

Use of water in the underground will be restricted. No washout or cleanup will be permitted in the underground except as designated by Westinghouse. Above ground washout or cleanup of equipment will be allowed in the areas designated by Westinghouse.

The Contractor is cautioned to be aware of the physical dimensions of the waste conveyance and the air lock.

The Contractor shall be responsible for any damage incurred by the existing site facilities as a result of his operations. Any damage shall be reported immediately to Westinghouse and repaired at the Contractor's cost.

3.4 Demobilization of Equipment and Facilities

At completion of this work, the Contractor shall demobilize his equipment and facilities from the job site. All Contractor's equipment and materials shall be removed and all disturbed areas restored. Utilities shall be removed to their connection points unless otherwise directed by Westinghouse.

3.5 Site Cleanup

At conclusion of the work, the Contractor shall remove all trash, waste, debris, excess construction materials, and restore the affected areas to their prior condition, to the satisfaction of

Westinghouse. A final inspection will be conducted by Westinghouse and the Contractor before final payment is approved.

End of section

SECTION 02222 EXCAVATION

PART 1 - GENERAL

1.1 Scope

This section includes:

- Excavation for surface preparation and leveling of surrounding areas for explosion isolation wall
- Disposition of excavated materials
- Field measurement and survey

1.2 Related Sections

- 01010 Summary of Work
- 01600 Material and Equipment
- 03400 Masonry Explosion Isolation Structure

1.3 Reference Documents

Krieg, R. D., 1984, "Reference Stratigraphy and Rock Properties for the Waste Isolation Pilot Plant," SAND83-1908, Sandia National Laboratories, Albuquerque, New Mexico.

1.4 Field Measurements and Survey

All survey required for performance of the work will be provided by Westinghouse.

PART 2 - PRODUCTS

Not used

PART 3 - EXECUTION

3.1 Excavation for Surface Preparation and Leveling of Surrounding Areas for Explosion Isolation Wall

The Contractor shall excavate and prepare the surface around the entire perimeter of the explosion isolation walls by removing all loose material, generally squaring the excavation cross-section, and cleaning all rock surfaces. The surface preparation of the floor shall produce a surface suitable for placing the first course of block in the explosion isolation walls. Excavation may be performed by either mechanical or manual means. Use of explosives is prohibited.

3.2 Disposition of Excavated Materials

The Contractor shall dispose of all excavated materials as directed by Westinghouse.

3.3 Field Measurements and Survey

All survey required for performance of the work will be provided by Westinghouse. The Contractor shall protect all survey control points, benchmarks, etc., from damage by his operations. Westinghouse will verify that the Contractor has excavated to the required lines and grades. No block work is to be erected until approved by Westinghouse.

End of section

SECTION 03100

MORTAR

PART 1 - GENERAL

1.1 Scope

This section includes:

• Mortar for Explosion Isolation Wall.

1.2 Related Sections

- 01010 Summary of Work
- 01400 Contractor Quality Control
- 01600 Material and Equipment
- 03300 Unit Masonry System
- 03400 Masonry Explosion Isolation Structure

1.3 References

ASTM C 91-01	Standard Specification for Masonry Cement
ASTM C 144-02	Standard Specification for Aggregate for Masonry Mortar
ASTM C 150-02	Standard Specification for Portland Cement
ASTM C 207-91	Standard Specification for Hydrated Lime for Masonry Purposes
ASTM C 270-01a	Standard Specification for Mortar for Unit Masonry
ASTM C 780-02	Standard Test Method for Preconstruction and Construction Evaluation of Mortars for Plain and Reinforced Unit Masonry
	·
ASTM C 1142-95	Standard Specification for Extended Life Mortar for Unit Masonry
ASTM C 94-00	Standard Specification for Ready-Mixed Concrete

1.4 Submittals for Review and Approval

The Contractor shall submit the followings 30 days prior to the initiation of work at the site:

- Design mix.
- Certified laboratory tests for the proposed design mix, indicating conformance of mortar to property requirements of ASTM C 270, and test and evaluation reports to ASTM C 780.

The mix shall not be used until approved by Westinghouse.

1.5 Submittals at Completion

The Contractor shall submit certified laboratory test results for the construction testing of mortar mix.

1.6 Quality Assurance

The Contractor shall:

- Perform work in accordance with the Contractor's Quality Control Plan and referenced ASTM standards.
- Acquire cement, aggregate, and component materials from the same source throughout the work.

1.7 Delivery Storage Handling

The Contractor shall maintain packaged materials clean, dry and protected against dampness, freezing and foreign matter.

PART 2 - PRODUCTS

2.1 Mortar Mix

The Contractor shall provide mortar for explosion isolation walls, which shall conform with ASTM C 270 type M, using the property specification 3,000 psi at 28 days as the minimum requirement. The Contractor shall provide the mortar design mix to achieve the minimum compressive strength requirement for masonry structure as specified in Section 03400. Aggregate for mortar shall conform to ASTM C 144.

2.2 Water

Water used in mixing concrete shall be of potable quality, free of injurious amounts of oil, acid, alkali, organic matter, or other deleterious substances. Water shall conform to the provisions in ASTM C 94, and in addition, shall conform to the following:

- PH not less than 6.0 or greater than 8.0
- Carbonates and/or bicarbonates of sodium and potassium: 1000 ppm maximum
- Chloride ions (Cl): 250 ppm maximum
- Sulfate ions (SO₄): 1000 ppm maximum
- Iron content: 0.3 ppm maximum
- Total solids: 2000 ppm maximum

The source of water is to be indicated and certified copies of test data from an approved laboratory confirming that the water to be used meets the above requirements shall be submitted for approval with the trial mix data.

The supply of materials as defined in the design mix shall remain the same throughout the job.

PART 3 - EXECUTION

3.1 General

The Contractor shall furnish all labor, materials, equipment, and tools to perform all operations in connection with supplying and mixing mortar for constructing the explosion isolation walls. The Contractor shall fully describe his proposed mortar mixing operation, including proposed equipment and materials in the Work Plan.

3.2 Mortar Mixing

Mortar shall be machine-mixed with sufficient water for a period of time not less than three minutes or more than ten minutes to achieve satisfactory workability. Maintain sand uniformly damp immediately before the mixing process. If water is lost by evaporation, retemper only within one and one half hours of mixing. Use mortar within two hours of mixing. Mortar which has hardened or stiffened due to hydration of the cement shall not be used.

3.3 Installation

The Contractor shall install mortar to the requirements of Section 03300 Unit Masonry System.

3.4 Field Quality Control

The Contractor shall provide a Quality Control Inspector to perform all sampling and testing to confirm that the mortar mix conforms to the proposed mix properties developed in the design mix.

Construction testing of mortar mix shall be in accordance with ASTM C 780 for compression strength. Four prism specimens shall be taken for each 50 ft³ of mortar or fraction thereof placed each day.

End of section

SECTION 03300

UNIT MASONRY SYSTEM

PART 1 – GENERAL

1.1 Scope

This section includes:

• Concrete Masonry Units

1.2 Related Sections

- 01010 Summary of Work
- 01400 Contractor Quality Control
- 01600 Material and Equipment
- 03100 Mortar
- 03400 Masonry Explosion Isolation Structure

1.3 References

ASTM C 55-01a Standard Specification for Concrete Brick

ASTM C 140-02 Standard Test Methods for Sampling and Testing Concrete Masonry Units

and Related Units

1.4 Submittals for Revision and Approval

The Contractor shall submit for approval the following 30 days prior to initiation of the work at the site.

• Certified laboratory test results for the proposed solid masonry units.

1.5 Quality Assurance

The Contractor shall perform the work in accordance with the CQCP.

PART 2 - PRODUCTS

2.1 Concrete Masonry Units

Concrete masonry units shall be solid (no cavities or cores), load-bearing, high-strength individual units having a minimum compressive strength of 5000 psi. Concrete masonry units shall be tested in accordance with ASTM C 140. All other aspects of the concrete masonry units shall comply with ASTM C 55, Type I Moisture Controlled.

Nominal modular size shall be 8x8x16 inches, or as otherwise approved by Westinghouse.

Concrete brick shall comply with ASTM C 55, Grade N, Type I (moisture controlled) but having a minimum compressive strength of 5500 psi (Avg. 3 units) or 5000 psi for individual unit.

2.2 Mortar

Mortar shall be as specified in Section 03100 Mortar.

PART 3 - EXECUTION

Not used

End of section

SECTION 03400

MASONRY EXPLOSION ISOLATION STRUCTURE PART 1 - GENERAL

1.1 Scope

This section includes:

Masonry Explosion Isolation Structure

1.2 Related Sections

- 01010 Summary of Work
- 01400 Contractor Quality Control
- 01600 Material and Equipment
- 03100 Mortar
- 03300 Unit Masonry Structure

1.3 References

ASTM C 1314-02a Standard Test Method for Compressive Strength of Masonry Prism

ACI 530.1-02 Specification for Masonry Structures

1.4 Submittals for Revision and Approval

The Contractor shall submit for approval the following 30 days prior to initiation of the work at the site.

• Certified laboratory test results for compressive strength of masonry by the prism method for a set of five masonry prisms. Materials used for the construction of the prisms shall be taken from those to be used in the construction of the explosion isolation wall. The minimum compressive strengths of the tests shall exceed f'_m as required in 1.6.

1.5 Quality Assurance

The Contractor shall perform the work in accordance with the CQCP.

1.6 Compressive Strength of Masonry

Compressive strength of masonry in each masonry wythe shall exceed 5000 psi (f'_m=5000 psi). The unconfined compressive strength shall be determined by prism test method in accordance with ASTM C 1314 and ACI 530.1.

PART 2 - PRODUCTS

2.1 Concrete Masonry Units

Concrete masonry units shall be as specified in Section 03300 Unit Masonry System. Concrete masonry units shall not be wetted unless otherwise approved by Westinghouse.

2.2 Mortar

Mortar shall be as specified in Section 03100 Mortar.

PART 3 - EXECUTION

3.1 General

The Contractor shall furnish all labor, material, equipment and tools to perform all operations of installing Unit Masonry Explosion Isolation Walls as shown on the Drawings.

The Contractor shall request that Westinghouse inspect and approve all surfaces before beginning any masonry work.

3.2 Installation

The Contractor shall install the explosion isolation walls using concrete masonry units as specified above. Masonry units shall be installed with 3/8-inch mortar joints with full mortar bedding and full head joints. The mortar shall be sufficiently plastic and units shall be placed with sufficient pressure to extrude mortar from the joint and produce a tight joint. Deep furrowing which produces voids shall not be used. The initial bed joint thickness shall not be less than 1/4 inch or more than 1 inch, subsequent bed joints shall be not less than 1/4 inch or more than 5/8 inch in thickness.

Masonry units shall be installed in running bond with headers every third course. Masonry units shall be mortared tight to the ribs and the back wall to provide a seal all around the explosion isolation wall. All surfaces shall be clean and free of deleterious materials.

Cut concrete blocks may be used as required to minimize the dimensional fit-up at the top or sides of the isolation walls. All interfaces between the explosion isolation wall and the rock

surfaces shall be completely mortared to provide full contact between the rock surfaces and the block wall.

Construction joints shall be left as shown on the Drawings. Construction joints shall be left open and unfilled.

3.3 Field Quality Control

The Contractor shall provide a Quality Control Inspector to inspect the installation of the Unit Masonry Explosion Isolation Walls. Inspection and testing of the mortar shall be in accordance with Section 03100 Mortar. Inspection and testing of masonry units are in accordance with Section 03300. A prism test in accordance with Part 1.6 of Section 03400 shall be performed for each 2000 ft³ of block wall.

End of section

SECTION 04100 SALT BACKFILL PART 1 - GENERAL

1.1 Scope

This section includes:

• Salt Backfill Placement

1.2 Related Sections

- 01010 Summary of Work
- 01400 Contractor Quality Control
- 01600 Material and Equipment

1.3 Submittals for Revision and Approval

The backfill emplacement method, dust control plan and other safety related material shall be approved by Westinghouse.

1.4 Quality Assurance

The Contractor shall perform the work in accordance with the CQCP.

PART 2 - PRODUCTS

2.1 Salt Backfill Material

The salt backfill is run of mine salt and requires no grading or compaction. The salt backfill shall be free of organic material.

PART 3 - EXECUTION

3.1 General

The Contractor shall furnish all labor, material, equipment and tools to handle and place the salt backfill.

The Contractor shall use underground equipment and underground mine personnel as required in Part 1.5 Work by Others in Section 01010 Summary of Work. Westinghouse will supply run of mine salt. The Contractor shall make suitable arrangements for transporting and placing the run of mine salt.

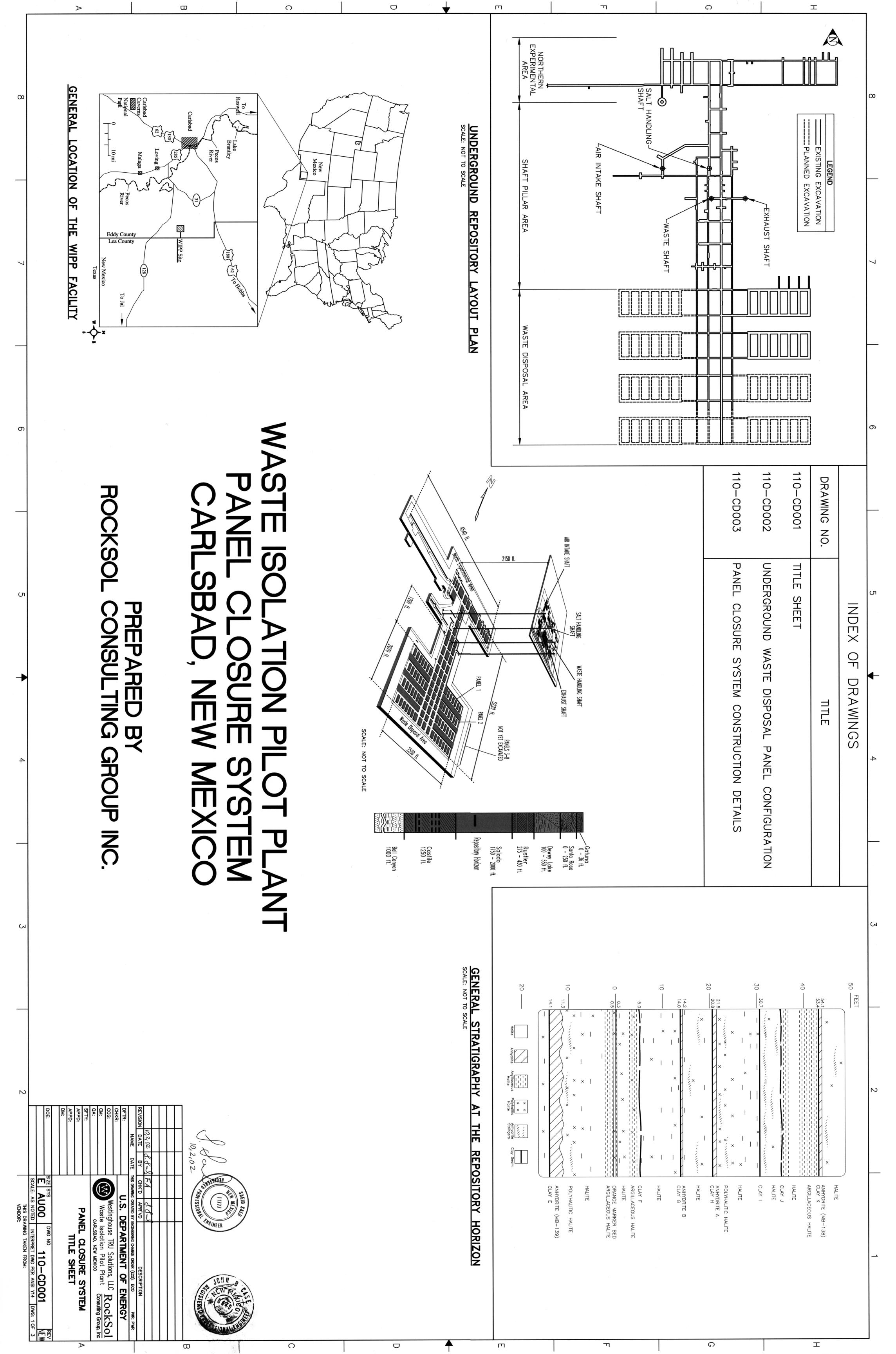
3.2 Installation

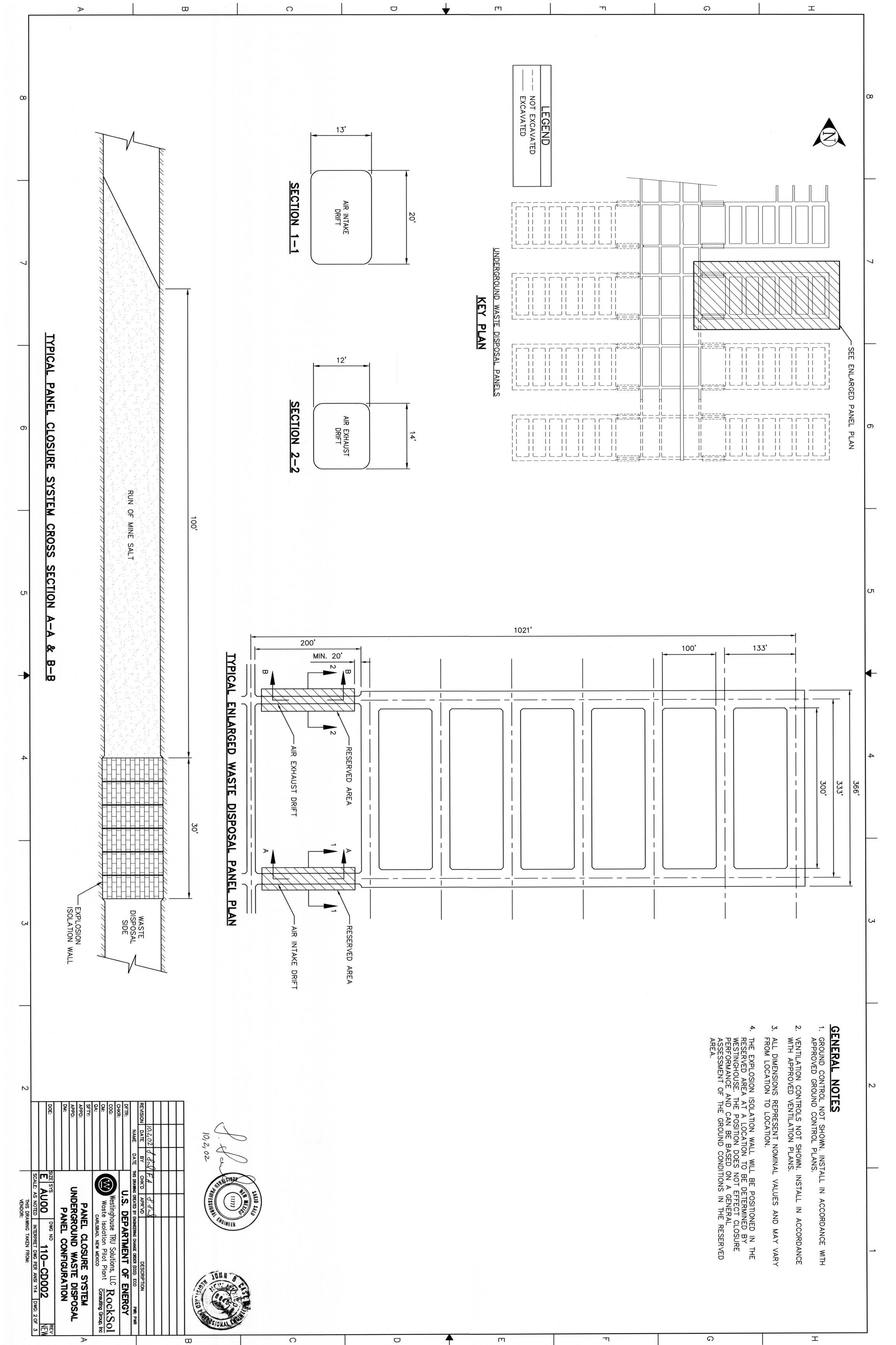
Run of mine salt shall be transported to the panel closure area after the construction of explosion isolation wall has been completed. Salt will be pushed against the explosion isolation wall until the entire opening is filled over the length and angle of layback as shown on Drawings. The salt may be left at the angle of repose or some lower slope, but shall not be less than 1 (rise) to 2 (run). There should be no gap left between backfill and roof or sidewalls. Hand placement can be used to fill all the voids if necessary. Backfill may be emplaced in layers to facilitate the construction.

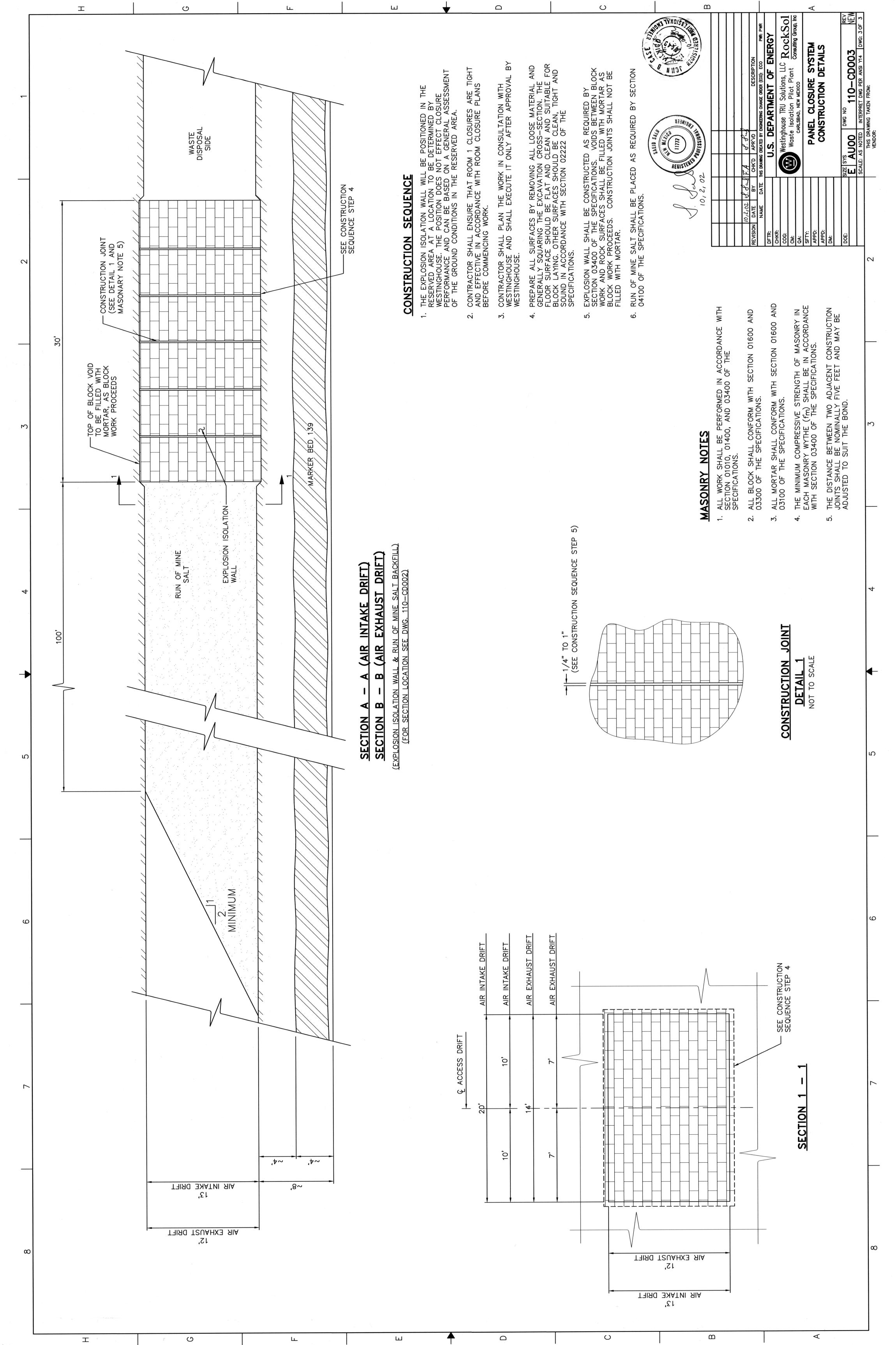
3.3 Field Quality Control

The Contractor shall provide a Quality Control Inspector to inspect the emplacement of backfill.

APPENDIX E DESIGN DRAWINGS







ATTACHMENT D

Proposed Changes to Attachment M2

Attachment M2, Section M2-2b

The anticipated schedule for the filling of each of the Underground HWDUs known as Panels 1 through 3 <u>is found in Permit Attachment I.</u> is as follows. The following assumptions are made in estimating the time to fill each HWMU:

- Throughput for CH waste is 784 drums per week (7 pallets per day, 4 days per week, 28 drums per pallet)
- The capacity of a panel is 81,000 drums

Under these assumptions, a minimum of 104 weeks is needed to emplace the waste. Allowing a 25 percent contingency for maintenance delays and time to transition from one room to another, it is estimated that a panel will be filled 2.5 years after emplacement is initiated. Panel closure in accordance with the Closure Plan in Permit Attachment I and Permit Attachment II is estimated to require an additional 150 days.



State of New Mexico ENVIRONMENT DEPARTMENT

Water and Waste Management Division Harold Runnels Building 1190 St. Francis Drive, P.O. Box 26110 Santa Fe, New Mexico 87502-6110 Telephone (505) 827-1758 Fax (505) 827-0310



JOHN R. D'ANTONIO, Jr. SECRETARY

CERTIFIED MAIL - RETURN RECEIPT REQUESTED

December 26, 2002

Dr. Inés Triay, Manager Carlsbad Field Office Department of Energy P. O. Box 3090 Carlsbad, New Mexico 88221-3090 Mr. John Lee, General Manager Westinghouse TRU Solutions LLC P.O. Box 2078 Carlsbad, New Mexico 88221-5608

RE: Final Determination, Class 1* Modification Request WIPP Hazardous Waste Facility Permit

EPA I.D. Number NM4890139088

Dear Dr. Triay and Mr. Lee:

On November 25, 2002, the New Mexico Environment Department (NMED) received a Class 1* permit modification request (PMR) for extension of time to perform closure of Panel 1 from the US Department of Energy Carlsbad Field Office and Westinghouse TRU Solutions, LLC (the Permittees). This request was submitted as a Class 1* modification requiring NMED approval prior to implementation, based upon an analysis of 20.4.1.900 NMAC (incorporating 40 CFR §270.42 Appendix I, Item D.1.b). This category of modification addresses "[c]hanges to the closure schedule for any unit, changes in the final closure schedule for the facility, or extension of the closure period, with prior approval of the Director." The Permittees further requested that NMED "issue a timely response regarding this proposal."

Prior to submittal of this PMR, the Permittees met with NMED representatives and interested members of the public on November 15, 2002 to discuss a draft PMR that outlined the technical and regulatory framework for requesting an extension to the closure schedule for Panel 1. At this meeting, the Permittees agreed to consider modifying this draft PMR to address concerns raised by various parties prior to formal

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submittal to NMED. The Permittees also agreed to provide NMED with an engineering analysis report (**Report**) describing the expected performance of a twelve-foot explosion isolation wall that would serve as the initial element of the panel closure system until a final panel closure design had been approved by both NMED and the US Environmental Protection Agency (**EPA**).

NMED notes for the record that, although the PMR was received November 25, 2002, the initial Report was not received until December 19, 2002. Following discussions with NMED, the Permittees submitted a revised Report incorporating a registered professional engineer's certification, which NMED received on December 23, 2002. NMED was unable to commence review of the full PMR until receipt of the Report. Thus, considering the revision to the Report and the need for appropriate review, NMED was precluded from issuing a final determination any earlier than today.

NMED has reviewed the PMR and revised Report and determined that together they constitute an administratively complete submittal. The New Mexico Hazardous Waste Fee Regulations require assessment of fees when administrative review of a document is complete, as specified in 20.4.2.301 NMAC. NMED will issue an invoice to you under a separate letter. Payment is due within sixty (60) calendar days from the date that you receive the invoice.

The proposed revised permit text in the PMR for Attachment I, Section I-1d(1), Schedule for Panel Closure does not provide a specific date or time period to satisfy the regulatory intent of a "closure schedule." In identifying the required elements of a closure plan, 20.4.1.500 NMAC (incorporating 40 CFR §264.112(b)(6)) states that a schedule for closure:

"... must include, at a minimum, the total time required to close each hazardous waste management unit and the time required for intervening closure activities which will allow tracking of the progress of partial and final closure."

Instead, the Permittees have proposed eliminating any deadline for completion of final closure of Panel 1 by stating on Page A-7 of the PMR:

"Subsequent closure activities will take place in conformity with this Permit as it may or may not be amended by final NMED administrative action on the panel closure design modification request submitted to NMED on October 7, 2002."

Although this proposed language change is a statement of the obvious (i.e., the Permittees must comply with the panel closure requirements of the permit), it does not provide a schedule in compliance with 20.4.1.500 NMAC (incorporating 40 CFR §264.112(b)(6)). NMED believes the Permittees may have used this language in an attempt to address the uncertainty associated with the timing of NMED's final agency

Dr. Inés Triay Mr. John Lee December 30, 2002 Page 3

action on the Class 3 panel closure design PMR, as well as to anticipate EPA's delay in reviewing the design change until after their recertification process is complete sometime in 2004.

Upon review of the Report, NMED has determined that the PMR must be altered to satisfy the regulatory requirements of a schedule for closure. This can be accomplished by linking the expected performance of the explosion isolation wall described in the Report to a specific schedule following completion of construction of the wall. NMED has modified the language in Attachment I, Section I-1d(1) to read as follows:

"The Permittees will initially block ventilation through Panel 1 as described in Permit Attachment M2 once Panel 1 is full to ensure continued protection of human health and the environment. The Permittees will then install the explosion isolation wall portion of the panel closure system that is described in Permit Attachment I1, Section 3.3.2, Explosion- and Construction-Isolation Walls. Construction of the explosion isolation wall will not exceed 180 days after the last receipt of waste in Panel 1. Final closure of Panel 1 will be completed as specified in this Permit no later than five years after completion of the explosion isolation wall."

Furthermore, NMED has modified Note 5 to Table I-1, Anticipated Earliest Closure Dates for the Underground HWMUs to read as follows:

"NOTE 5: The anticipated closure end date for Panel 1 is for installation of the 12-foot explosion isolation wall. Final closure of Panel 1 will be completed as specified in this Permit no later than five years after completion of the explosion isolation wall."

EPA clarified the use of Class 1* modifications in the preamble to the permit modification final rule (53 Fed. Reg. 37915, September 28, 1988), where it states:

"As proposed, EPA is allowing certain Class 1 modifications – such as changes in interim dates in schedules of compliance or minor changes in incinerator trial burns – only after the permitting Agency has approved the modification. This provision is container in §270.42(a)(2). Those Class 1 modifications which require prior Agency approval are identified in Appendix I with an asterisk. This approval procedure is analogous to the former minor modification procedures. The Permittees must notify persons on the facility mailing list within 90 calendar days after the Director approves the request."

As stated in the first paragraph of this final determination, the Permittees submitted this PMR after identifying it in Appendix I of 40 CFR §270.42 as Item D.1.b. NMED

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concludes that the PMR, as modified to incorporate an enforceable closure schedule, is appropriately classified as a Class 1* modification.

NMED hereby approves, with changes noted above, the Class 1* modification to the Permit extending the time to perform closure of Panel 1. NMED will issue a revision to the WIPP Hazardous Waste Facility Permit within thirty (30) days reflecting the changes approved by this final determination.

If you have any questions regarding this matter, please contact Steve Zappe at (505) 428-2517.

Sincerely,

John R. D'Antonio, Jr. Secretary

JRD/soz

cc: Paul Ritzma, NMED

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